

DCA distributions with INTT

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Introduction

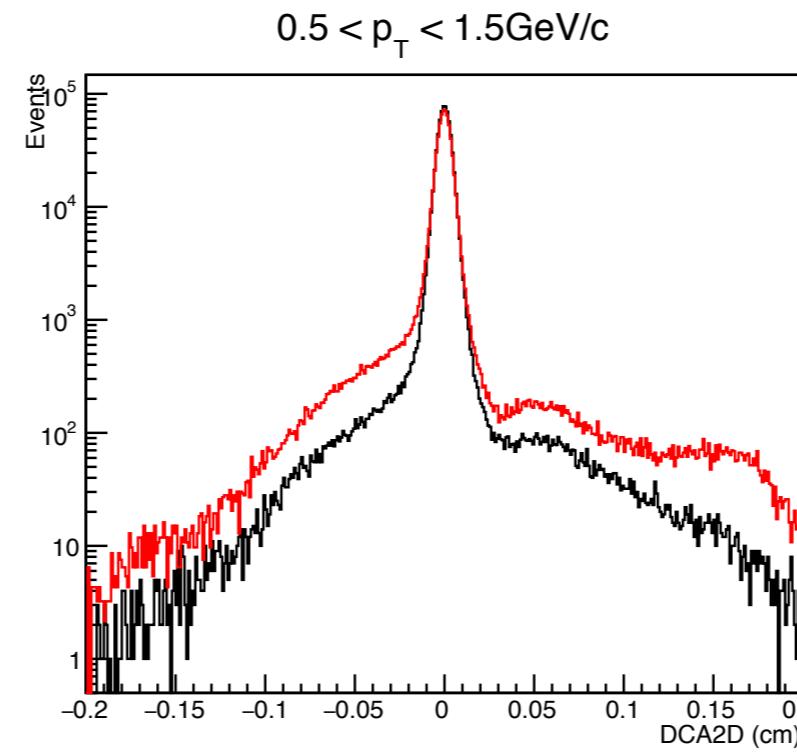
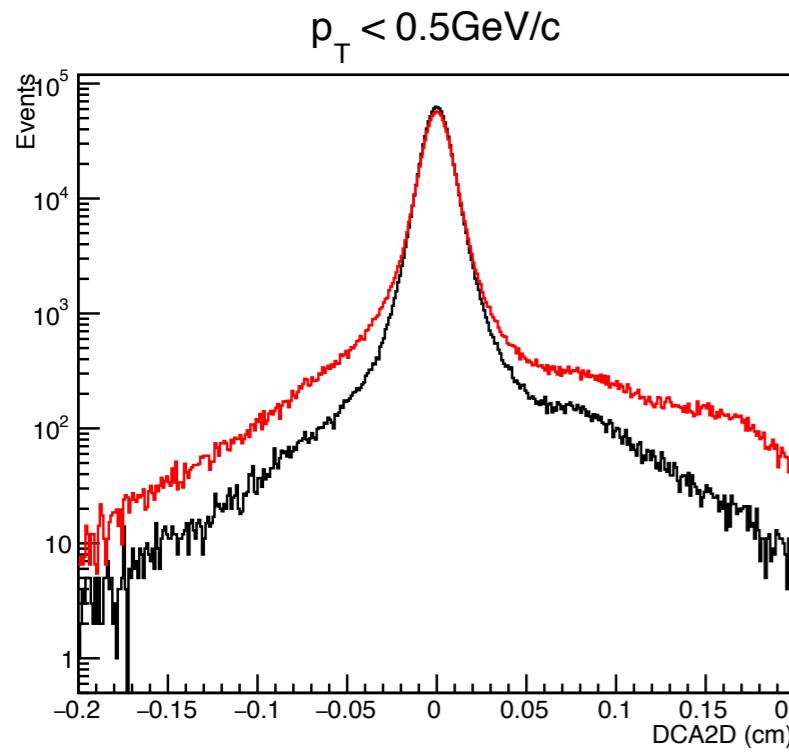
- I looked at the DCA2D distributions in some detector configurations, e.g. 3 MAPS + 60 TPC, 3 MAPS + 4 INTT + 60 TPC, etc...
 - Especially focusing on a comparison between with and without INTT.
- I found several questionable behaviors in the DCA2D distributions no matter what inner tracking layers.
 - No conclusion today, but it maybe worth to share what I found.

Simulation methodology

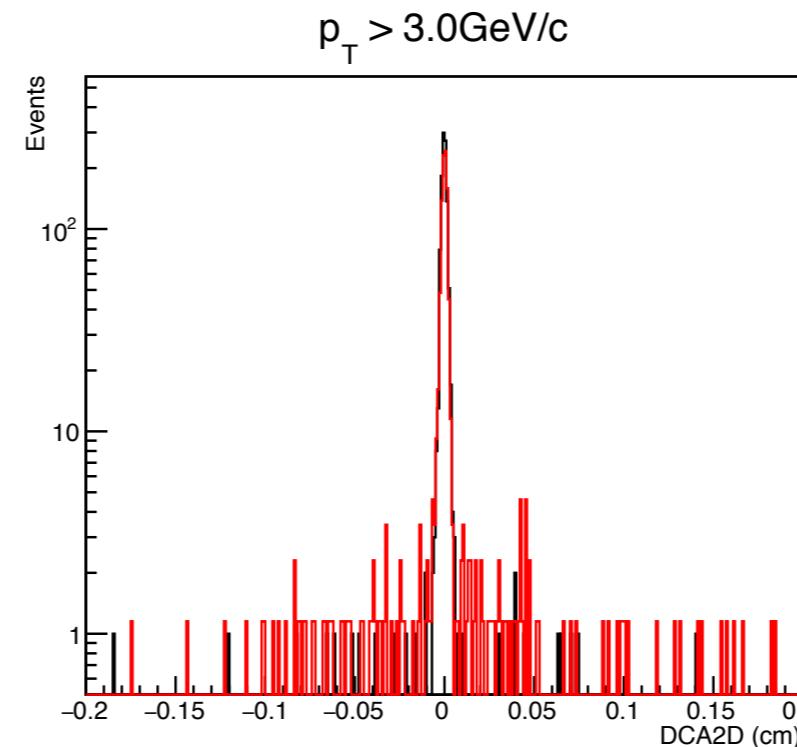
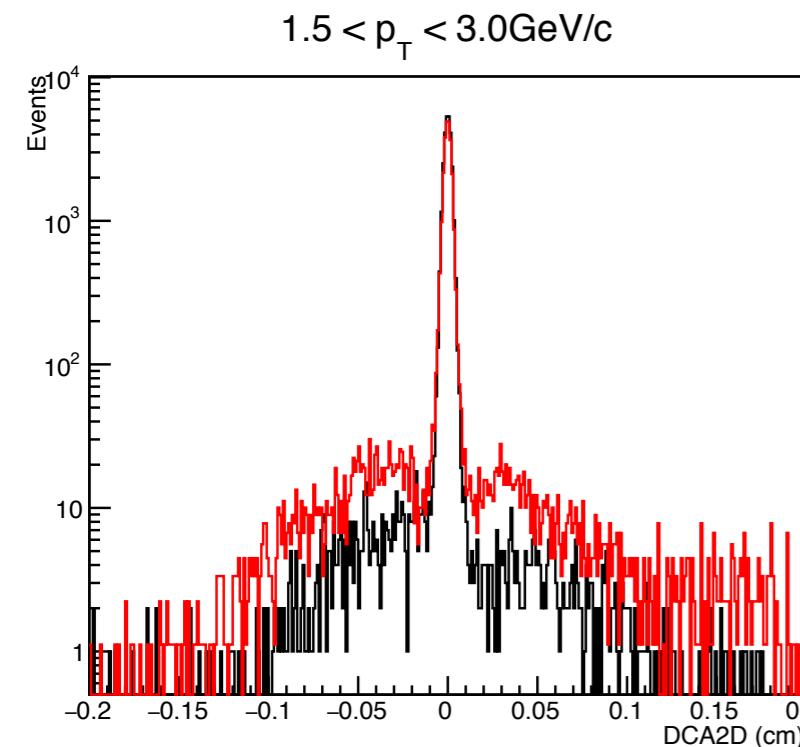
- sPHENIX Geant4 simulation is used.
 - No customization except for slight changes in the detector configuration “G4_Svtx_maps+tpc.C”.
 - MAPS (R=2.3, 3.2, and 3.9 cm) [3.2 cm? 3.1 cm?]
 - Intermediate tracker “INTT” (R=6, 8, 10, and 12 cm)
 - TPC 60 layers until R=80 cm.
 - In the following slides, “Config. A.B” means the numbers of **MAPS** and **INTT** layers are **A** and **B**, respectively.
- Basically I input central HIJING events, and also Pythia8 (HardQCD:all = off & HardQCD:hardbbbar = on) to check the DCA distributions for low-multiplicity events.
- GhostRejection(true) and Chi2/ndf < 2.0 cut are applied.

Config. 3.0 vs. Config. 3.4

Central HIJING



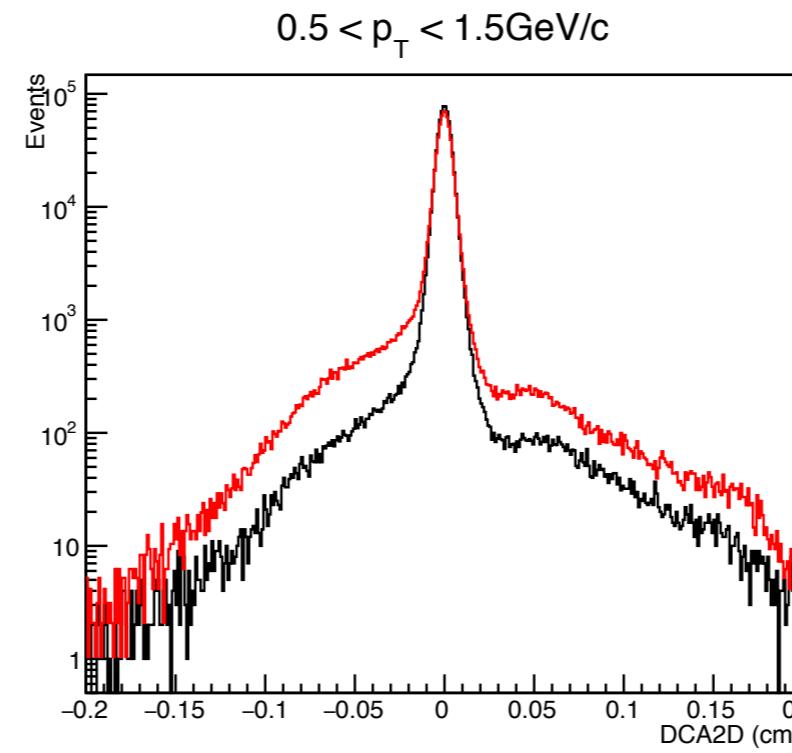
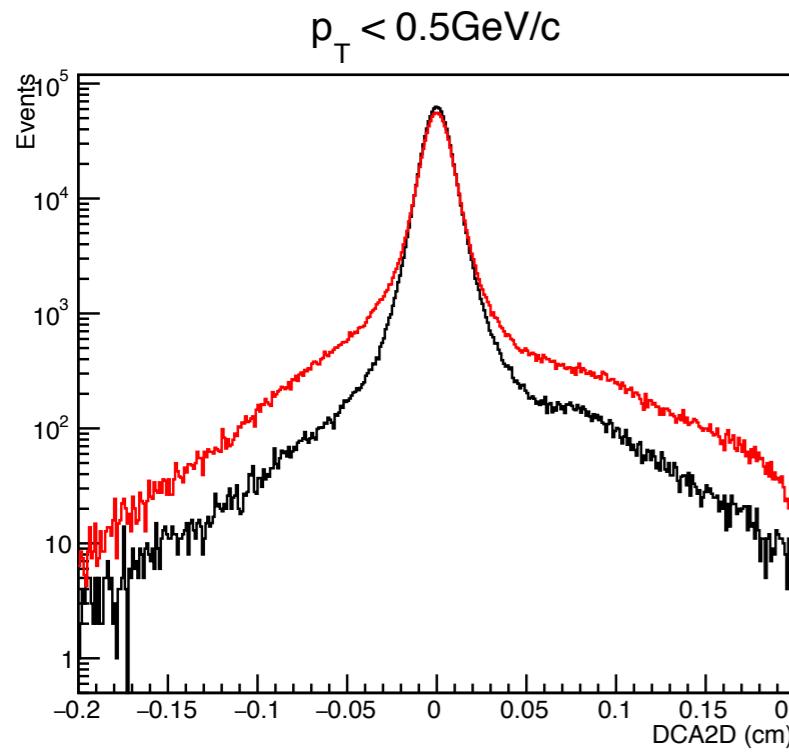
	Config. 3.0	Config. 3.4
MAPS	3	3
Si-tracker	0	4
TPC	60	60



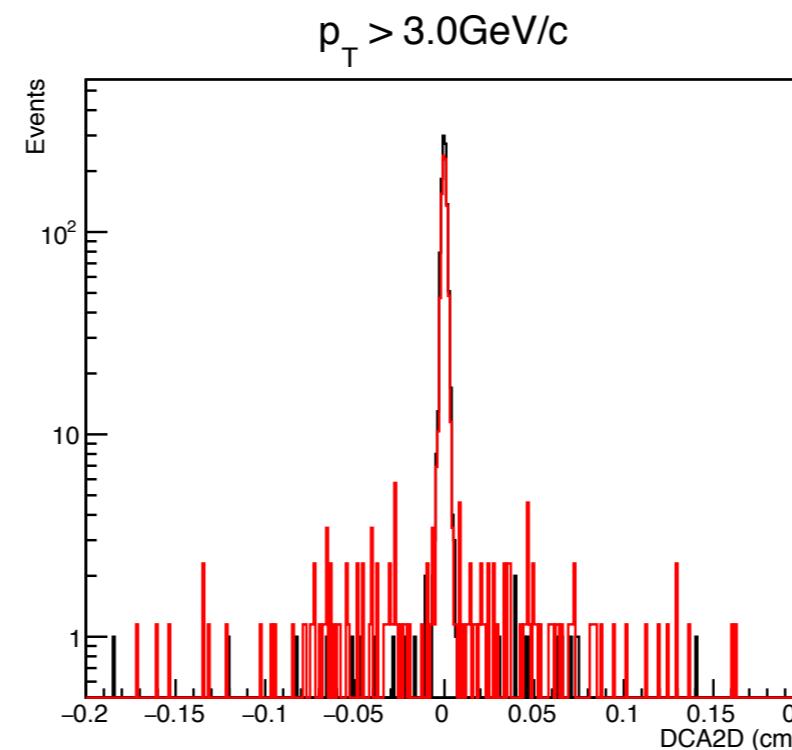
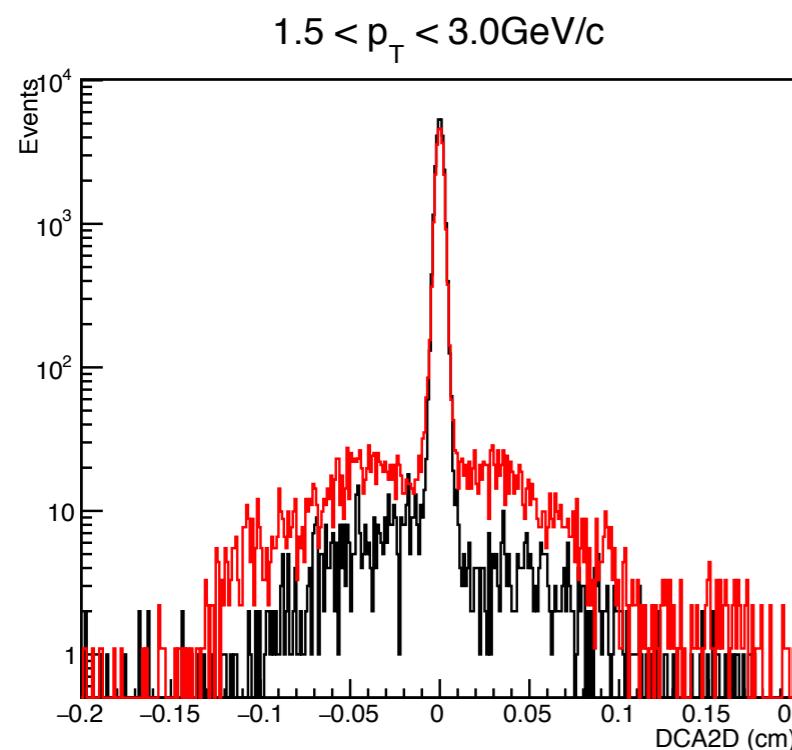
Si-tracker somehow adds large DCA events. Naively I expect additional tracking layers helps to reduce background level...

Config. 3.0 vs. Config. 3.5

Central HIJING



	Config. 3.0	Config. 3.5
MAPS	3	3
Si-tracker	0	5
TPC	60	60

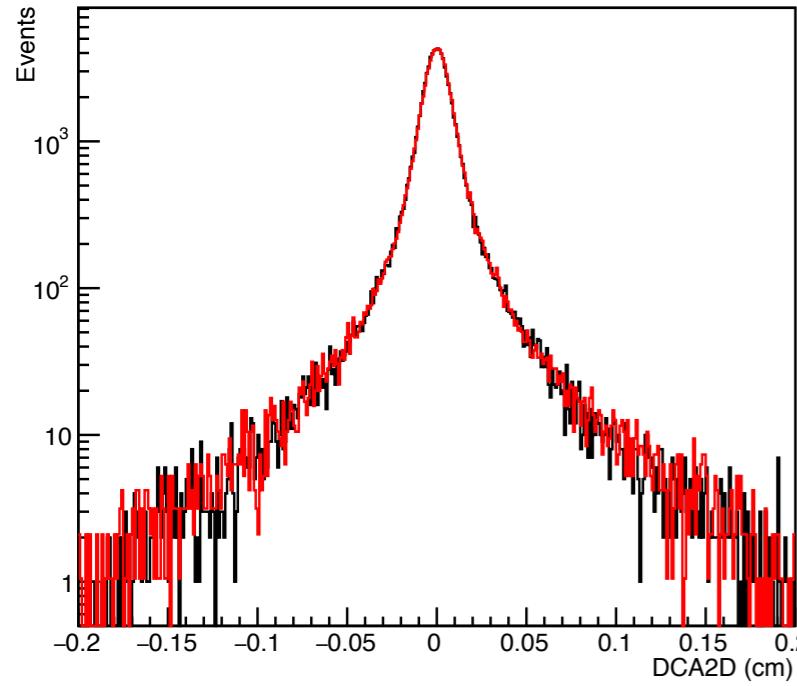


Si-tracker somehow adds large DCA events. Strips in one of the five Si-layers placed at $R = 5\text{ cm}$ are oriented to φ directions namely it is sensitive to z-dir.

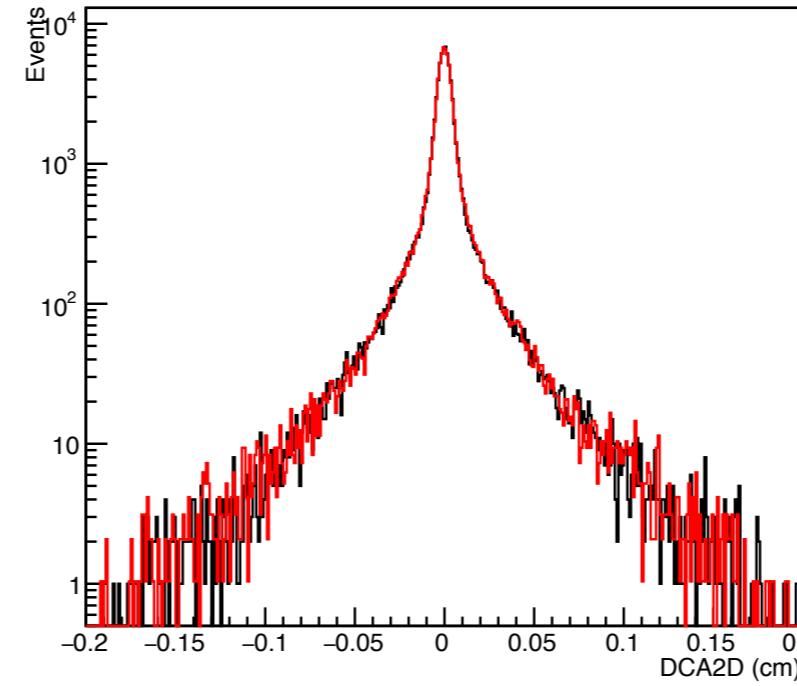
Config. 3.0 vs. Config. 3.5

PYHITA8 b+bbar

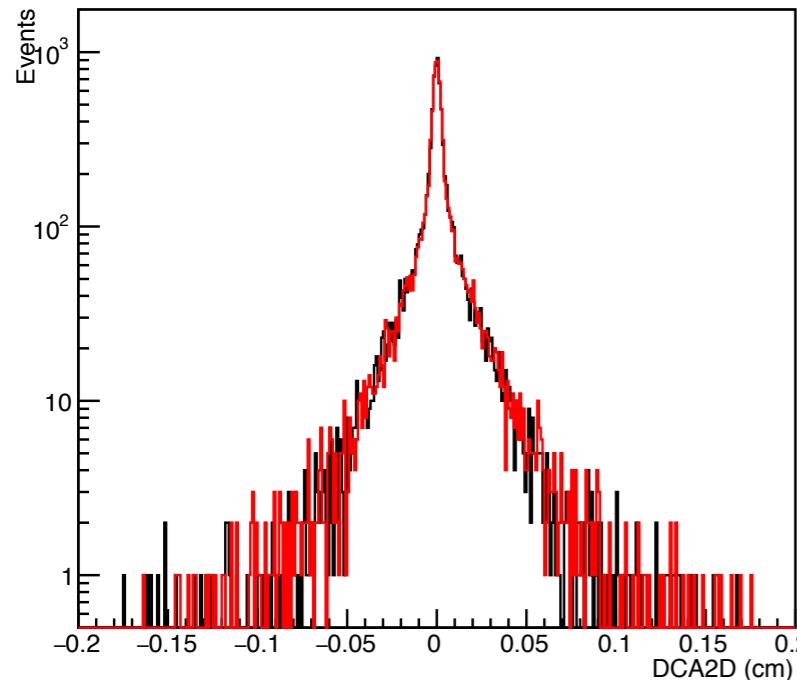
$p_T < 0.5\text{GeV}/c$



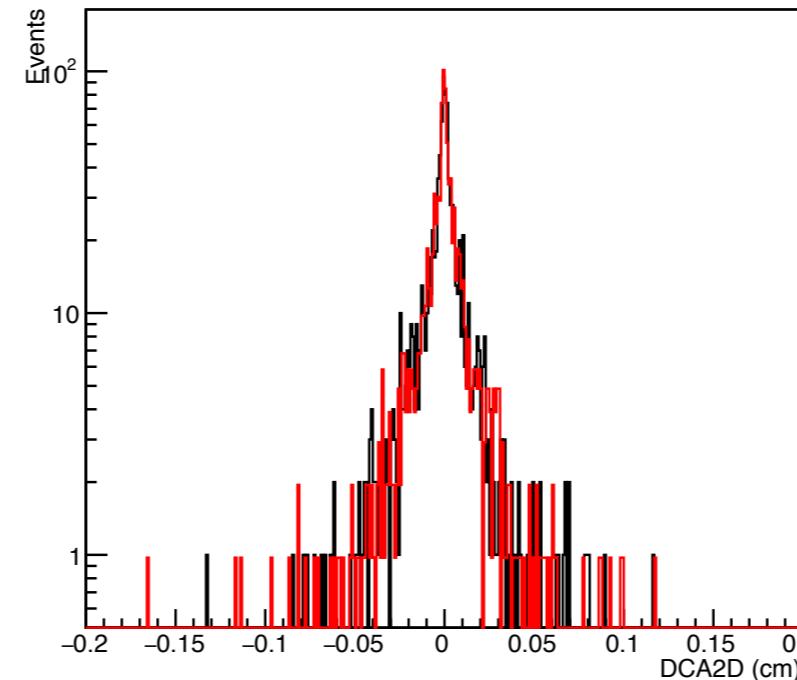
$0.5 < p_T < 1.5\text{GeV}/c$



$1.5 < p_T < 3.0\text{GeV}/c$



$p_T > 3.0\text{GeV}/c$



	Config. 3.0	Config. 3.5
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MAPS

3

Si-tracker

0

TPC

60

60

It looks OK in low-multiplicity events. Strips in one of the five Si-layers placed at R = 5 cm are oriented to ϕ directions namely it is sensitive to z-dir.

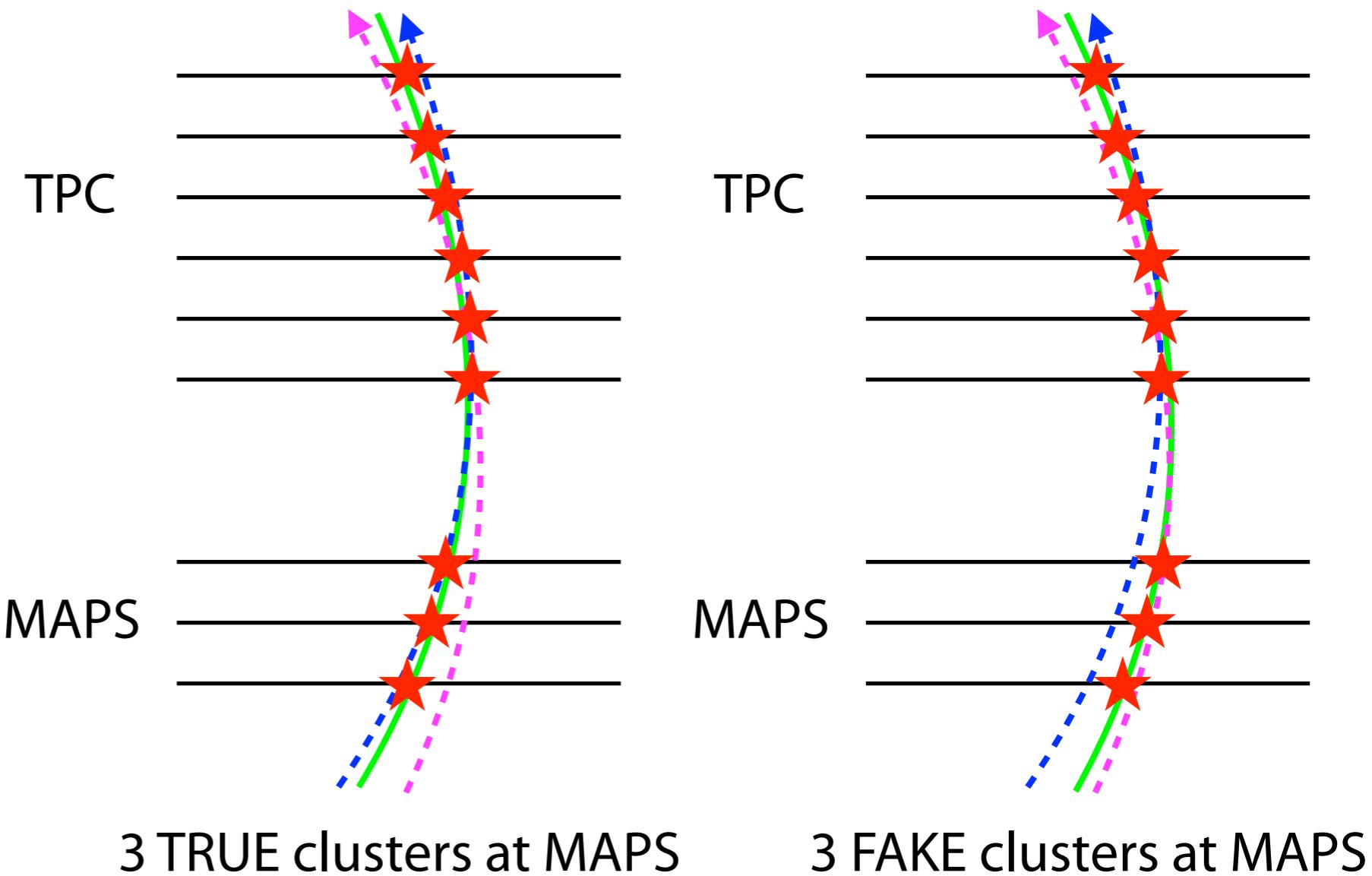
Breakdown of the DCA distributions

Green: Reco. track

Blue: True particle

Magenta: Fake particles

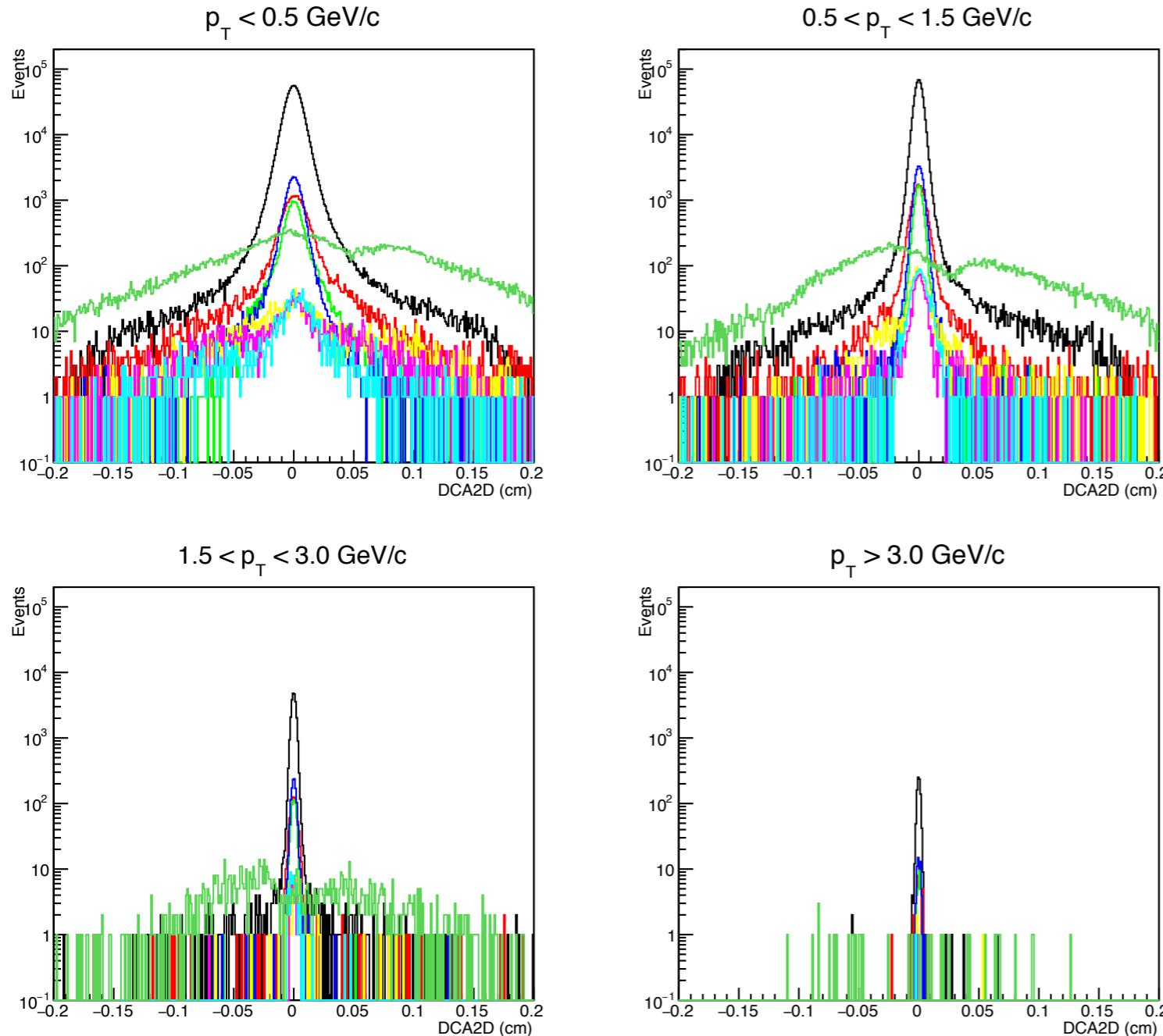
Red: Clusters on reco. track



- A given particle that makes a largest number of clusters on reco. track is regarded as “True particle”.
- DCA distributions should be sensitive to clusters on reco. track at MAPS; if all clusters are made by True (Fake) particle, DCA distributions would be narrow (broad.)

Config. 3.0

Central HIJING



Large DCA background events are dominated by "FAKE&FAKE&FAKE" ~ 5%.

The number of inner layers = 3

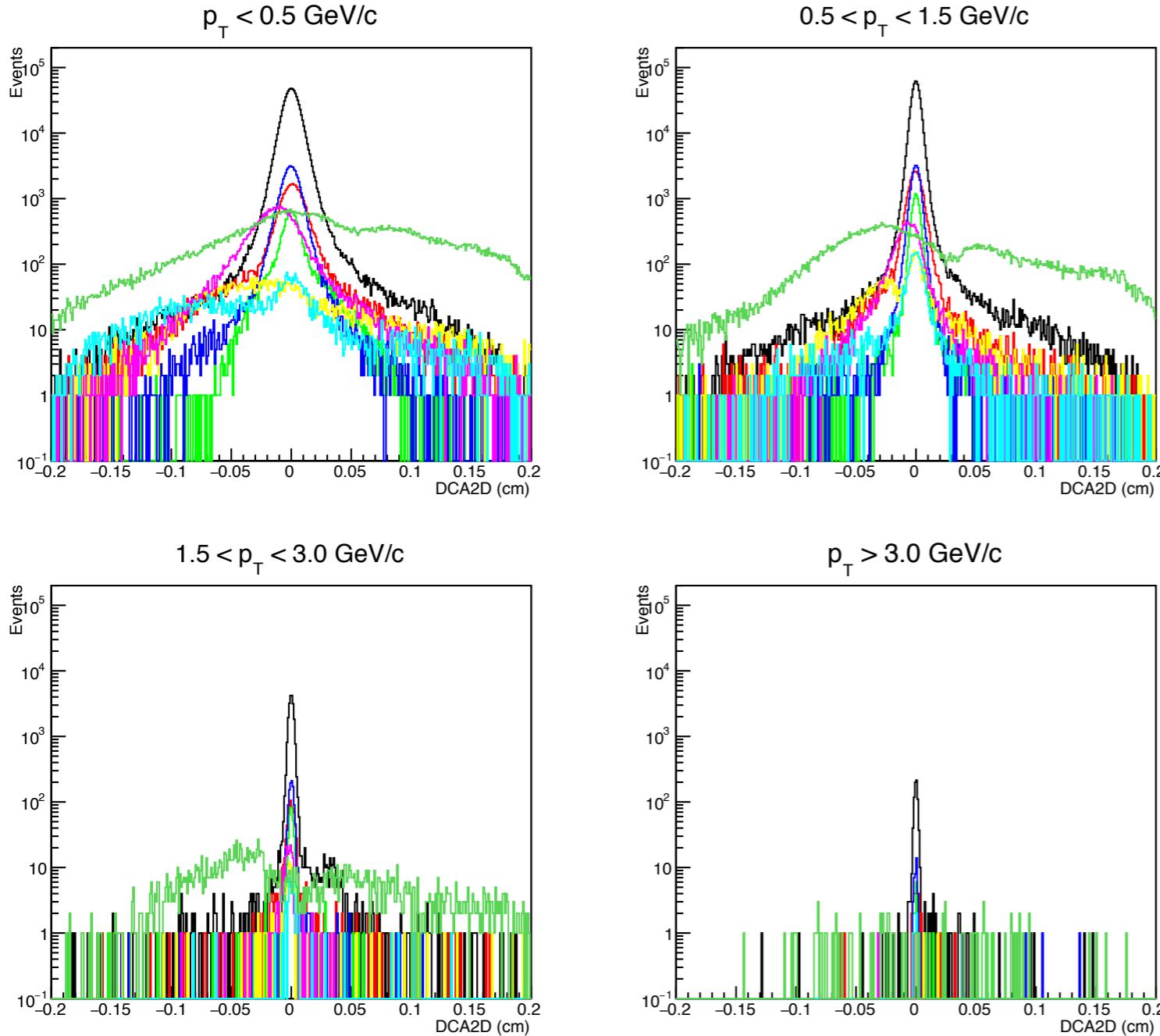
		MAPS layer		
		0	1	2
Black	TRUE	TRUE	TRUE	
	Red	FAKE	TRUE	TRUE
Green	TRUE	FAKE	TRUE	
Blue	TRUE	TRUE	FAKE	
Yellow	FAKE	FAKE	TRUE	
Magenta	TRUE	FAKE	FAKE	
Cyan	FAKE	TRUE	FAKE	
Moss green	FAKE	FAKE	FAKE	

Ratios to sum of histograms

	Black	Red	Green	Blue	Yellow	Magenta	Cyan	Moss green
<0.5GeV	0.867	0.029	0.016	0.032	0.002	0.002	0.001	0.049
0.5-1.5GeV	0.856	0.036	0.020	0.042	0.003	0.002	0.002	0.040
1.5-3.0GeV	0.860	0.033	0.022	0.043	0.002	0.001	0.002	0.036
>3.0GeV	0.834	0.042	0.031	0.053	0.004	0.003	0.002	0.033

Config. 3.4

Central HIJING



Fraction of "FAKE&FAKE&FAKE" increases to the twice of Config. 3.0.
DCA mean of Magenta is shifted to negative.

9

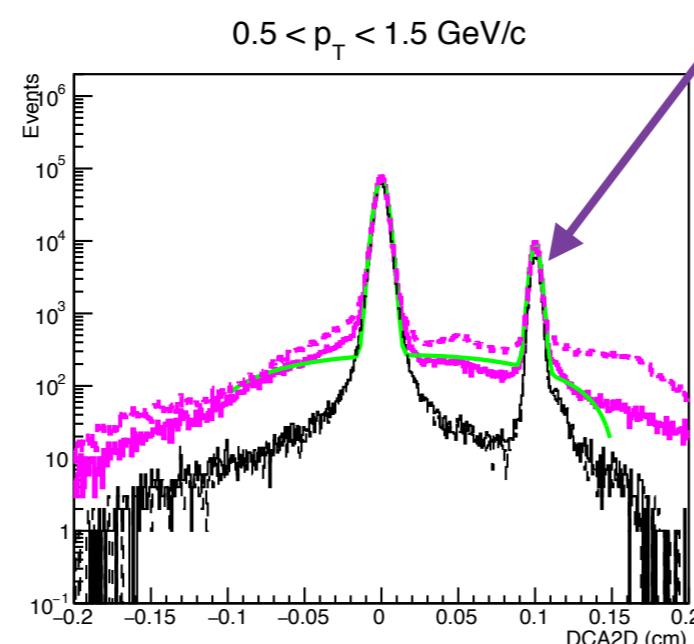
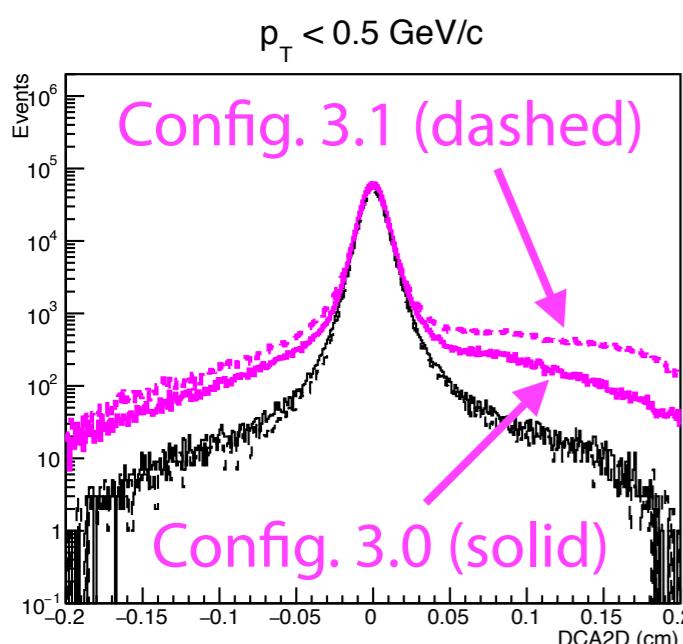
The number of inner layers = 7

	MAPS layer		
	0	1	2
Black	TRUE	TRUE	TRUE
Red	FAKE	TRUE	TRUE
Green	TRUE	FAKE	TRUE
Blue	TRUE	TRUE	FAKE
Yellow	FAKE	FAKE	TRUE
Magenta	TRUE	FAKE	FAKE
Cyan	FAKE	TRUE	FAKE
Moss green	FAKE	FAKE	FAKE

Ratios to sum of histograms

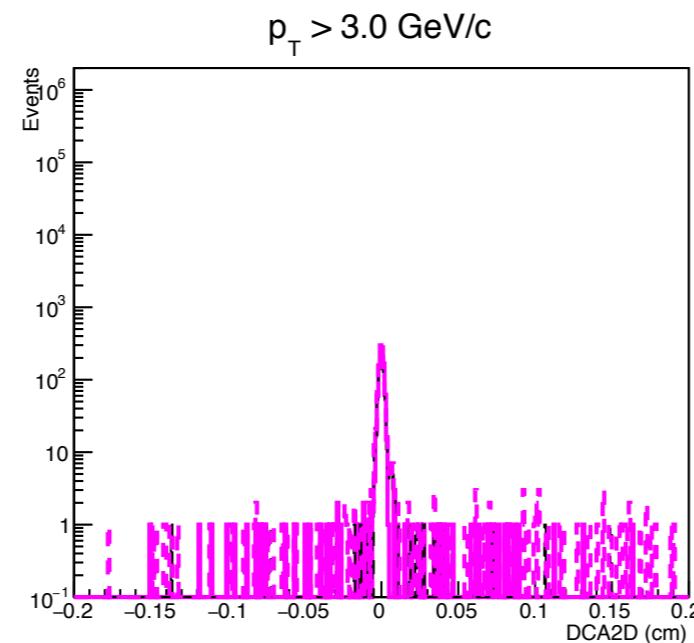
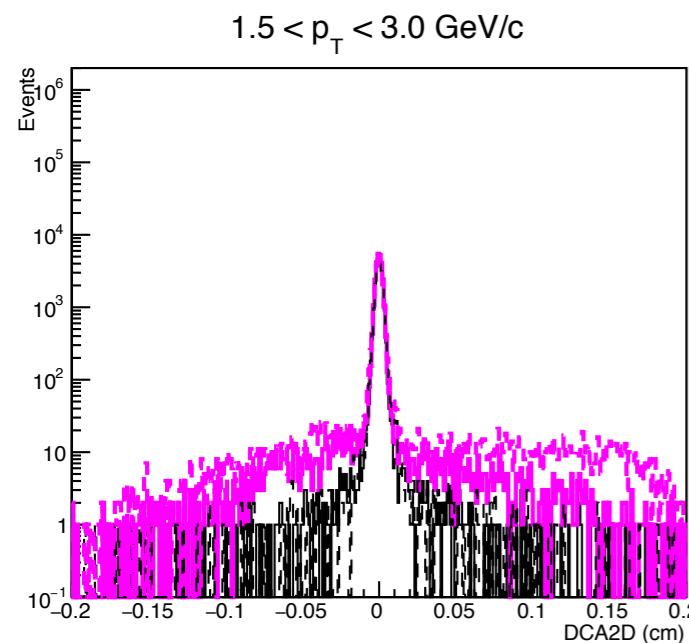
	Black	Red	Green	Blue	Yellow	Magenta	Cyan	Moss green
<0.5GeV	0.752	0.042	0.013	0.053	0.007	0.032	0.005	0.096
0.5-1.5GeV	0.786	0.055	0.015	0.043	0.007	0.015	0.004	0.075
1.5-3.0GeV	0.820	0.032	0.016	0.042	0.005	0.007	0.002	0.076
>3.0GeV	0.810	0.035	0.017	0.045	0.004	0.002	0.006	0.082

Config. 3.0 (solid) vs. Config. 3.1 (dashed)



Artificial events firing from DCA=0.1cm,
please ignore for the moment.

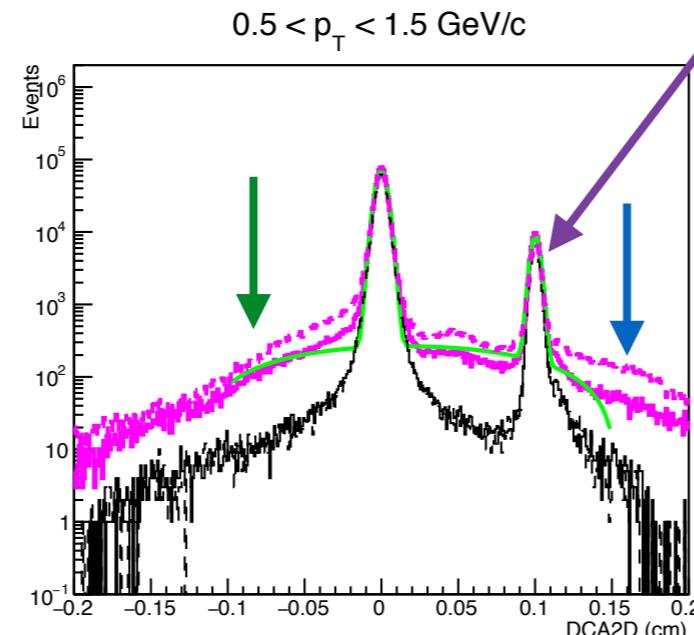
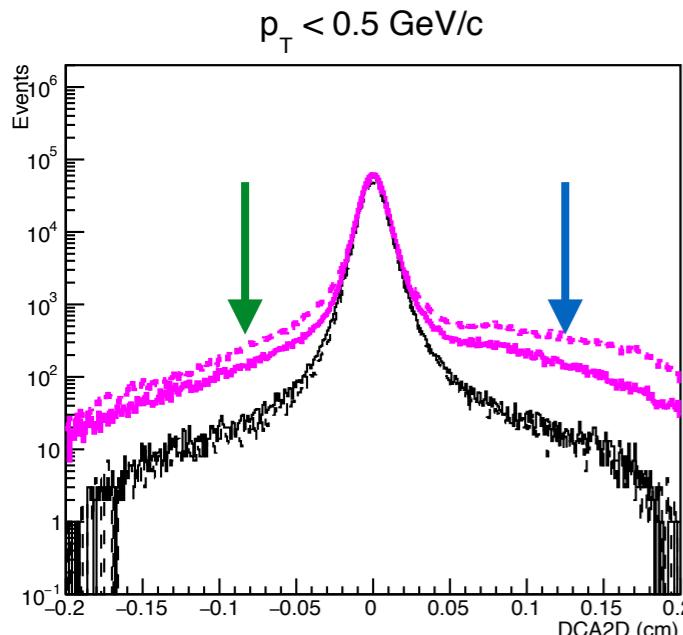
		MAPS layer		
		0	1	2
Black	TRUE	TRUE	TRUE	
	Magenta	Sum of all combinations		



I checked how the number of INTT layer affects to the BG level.
(note that one INTT layer $\sim 0.8\%/\chi_0$.)

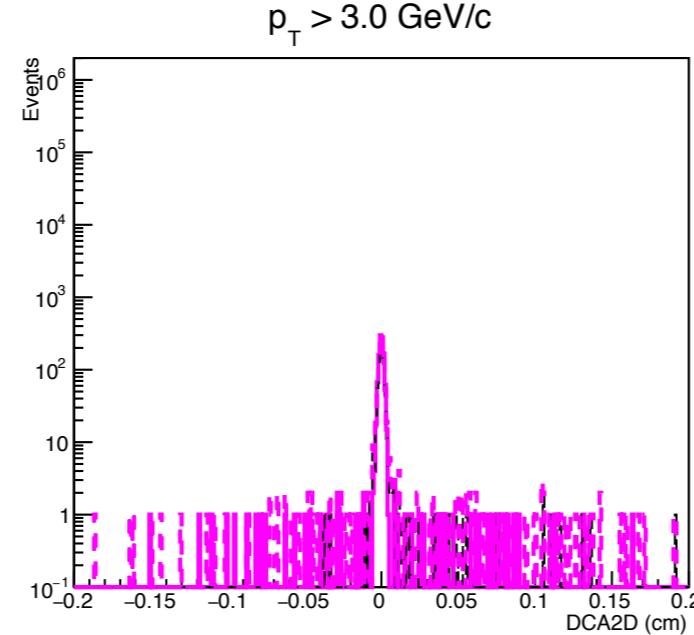
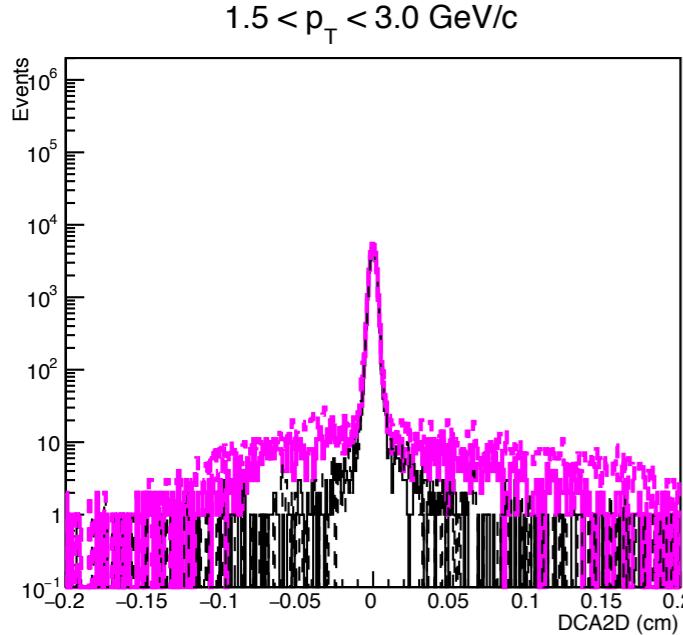
Even only one INTT layer increases
BG level and increasing somewhat
significantly at positive DCA2D.

Config. 3.0 (solid) vs. Config. 3.2 (dashed)

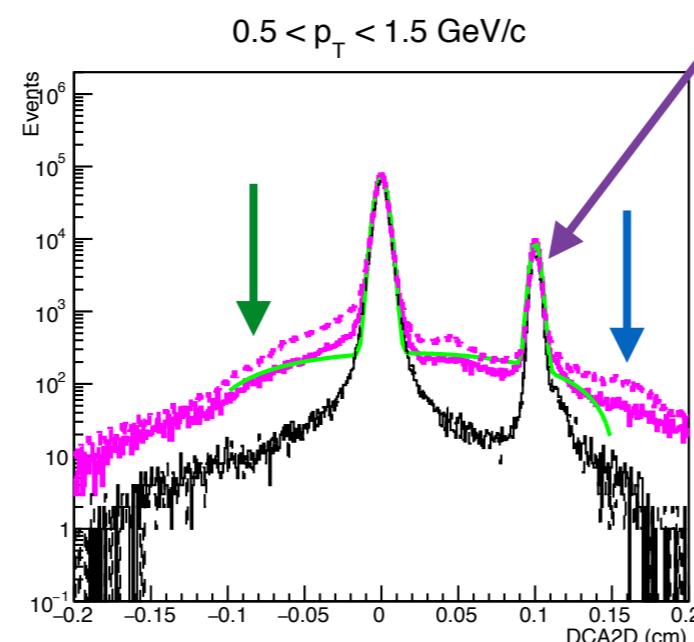
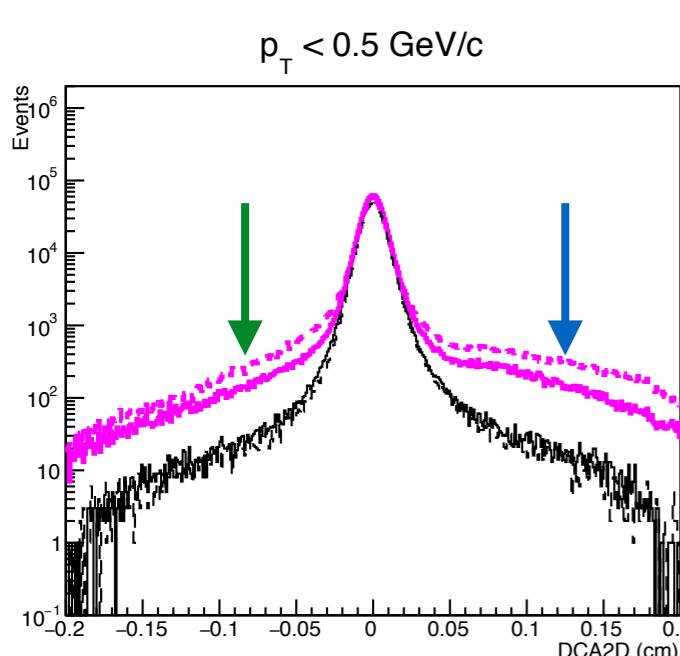


Artificial events firing from DCA=0.1cm,
please ignore for the moment.

		MAPS layer		
		0	1	2
Black	TRUE	TRUE	TRUE	
	Magenta	Sum of all combinations		

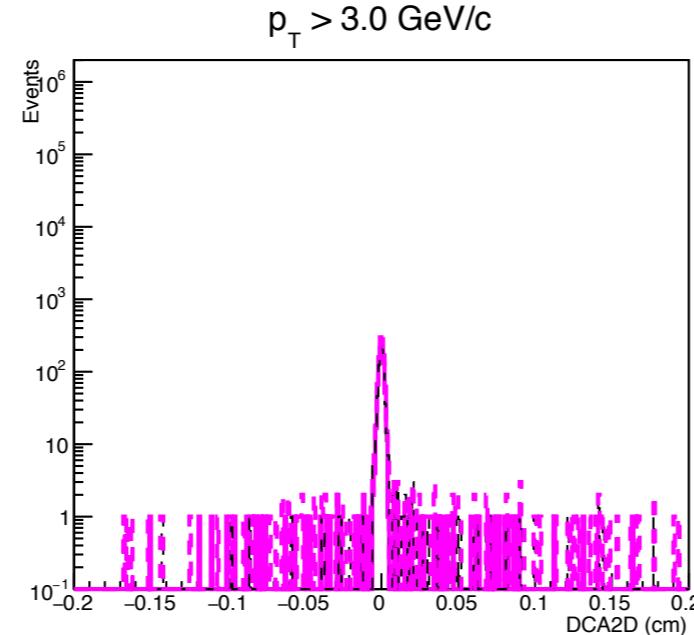
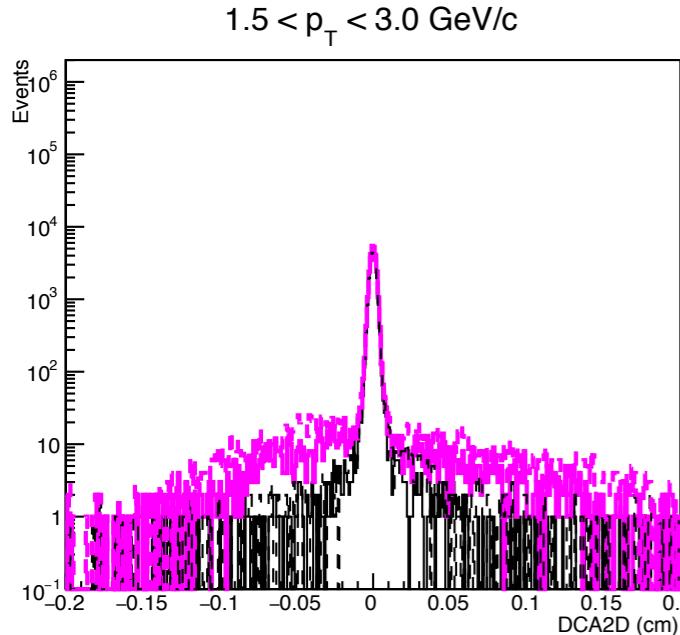


Config. 3.0 (solid) vs. Config. 3.3 (dashed)

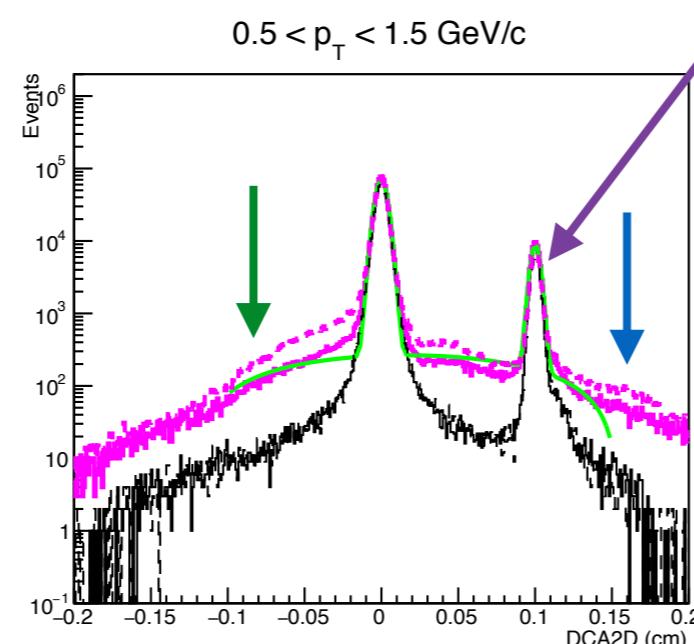
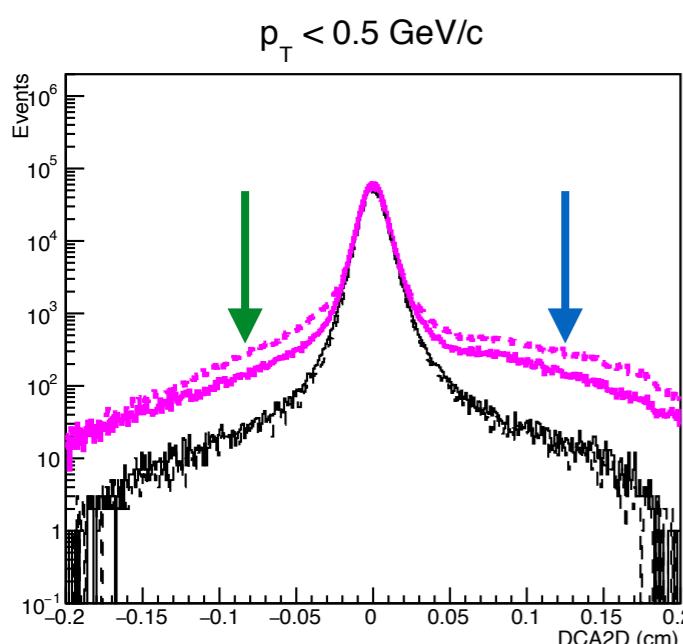


Artificial events firing from DCA=0.1cm,
please ignore for the moment.

		MAPS layer		
		0	1	2
Black	TRUE	TRUE	TRUE	
	Magenta	Sum of all combinations		

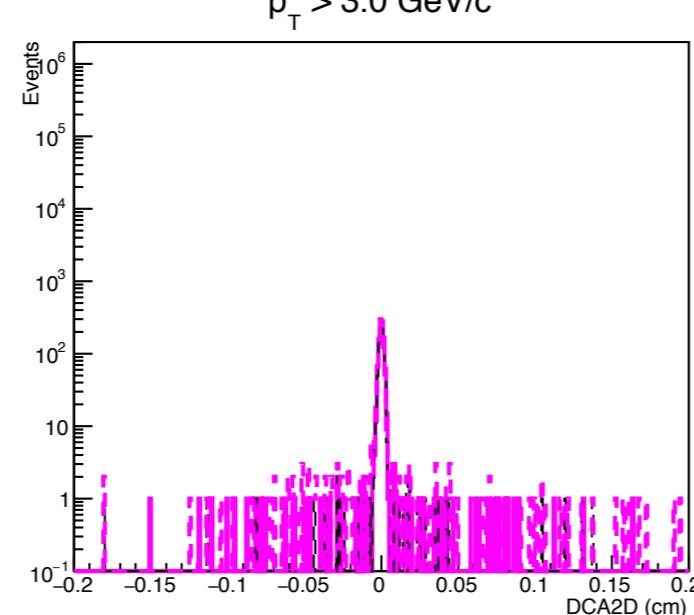
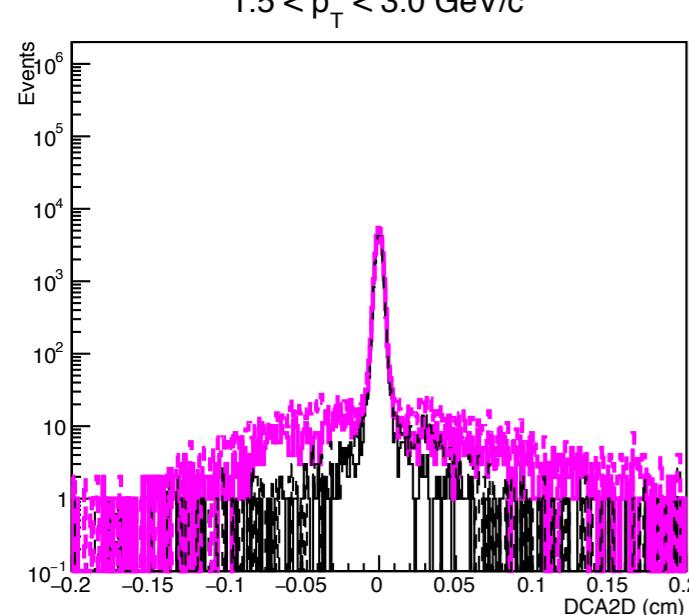


Config. 3.0 (solid) vs. Config. 3.4 (dashed)



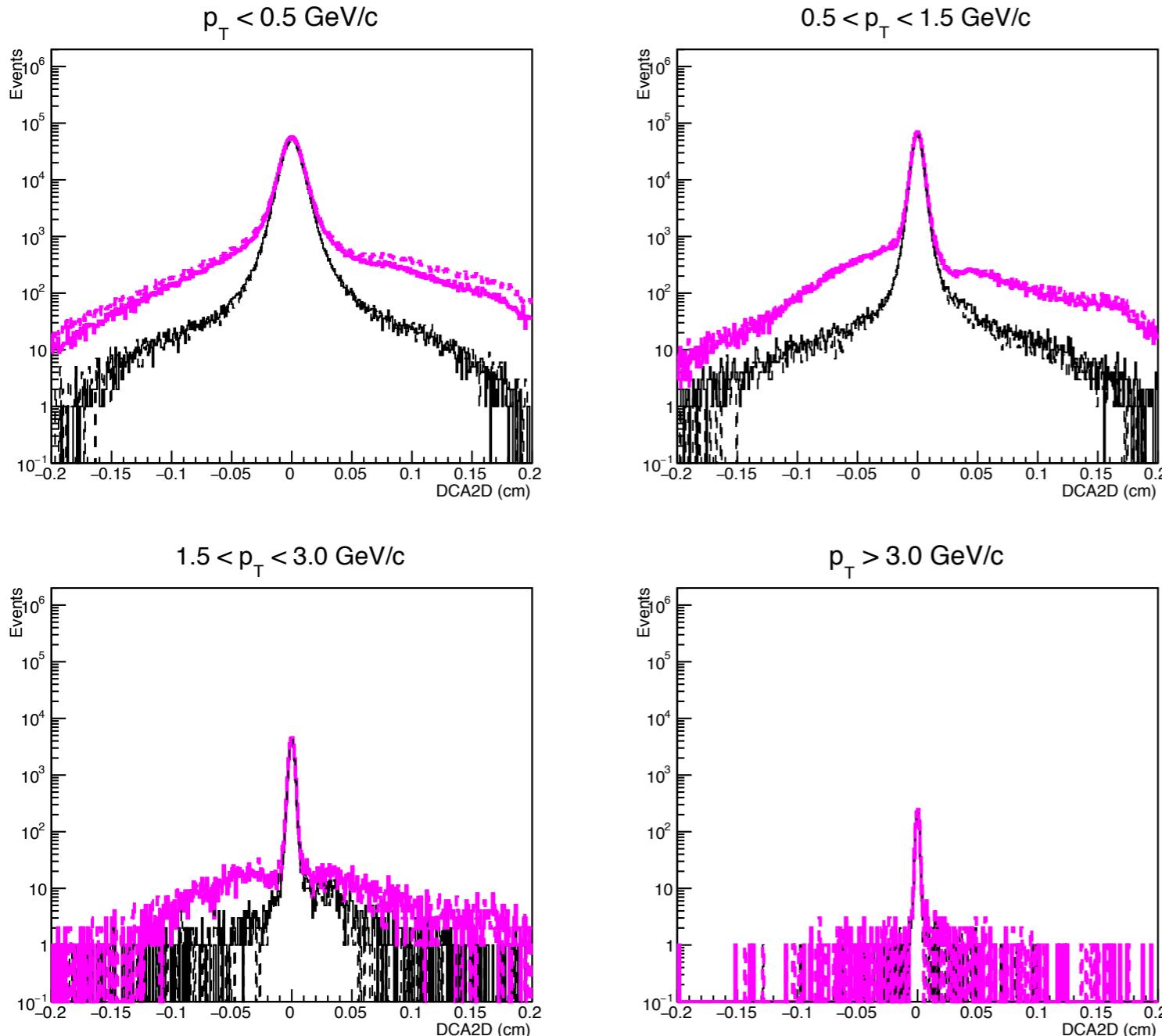
Artificial events firing from DCA=0.1cm,
please ignore for the moment.

		MAPS layer		
		0	1	2
Black	TRUE	TRUE	TRUE	
	Magenta	Sum of all combinations		



Why does the BG level **increase in negative DCA (decrease in positive DCA)** as the number of INTT layer increases?

Config. 3.4A (solid) vs. Config. 3.4 (dashed)



	MAPS layer		
	0	1	2
Black	TRUE	TRUE	TRUE
Magenta	Sum of all combinations		

- Config. 3.4A (dashed) is a modification of Config. 3.4 (solid), replacing the thickness of Si and Cu with those of MAPS.
- Difference between Config. 3.4 and 3.4A is significantly smaller than that between 3.0 and 3.4.
- Do other sources than material budget increase BG level?

Why INTT increases the fraction of BGs?

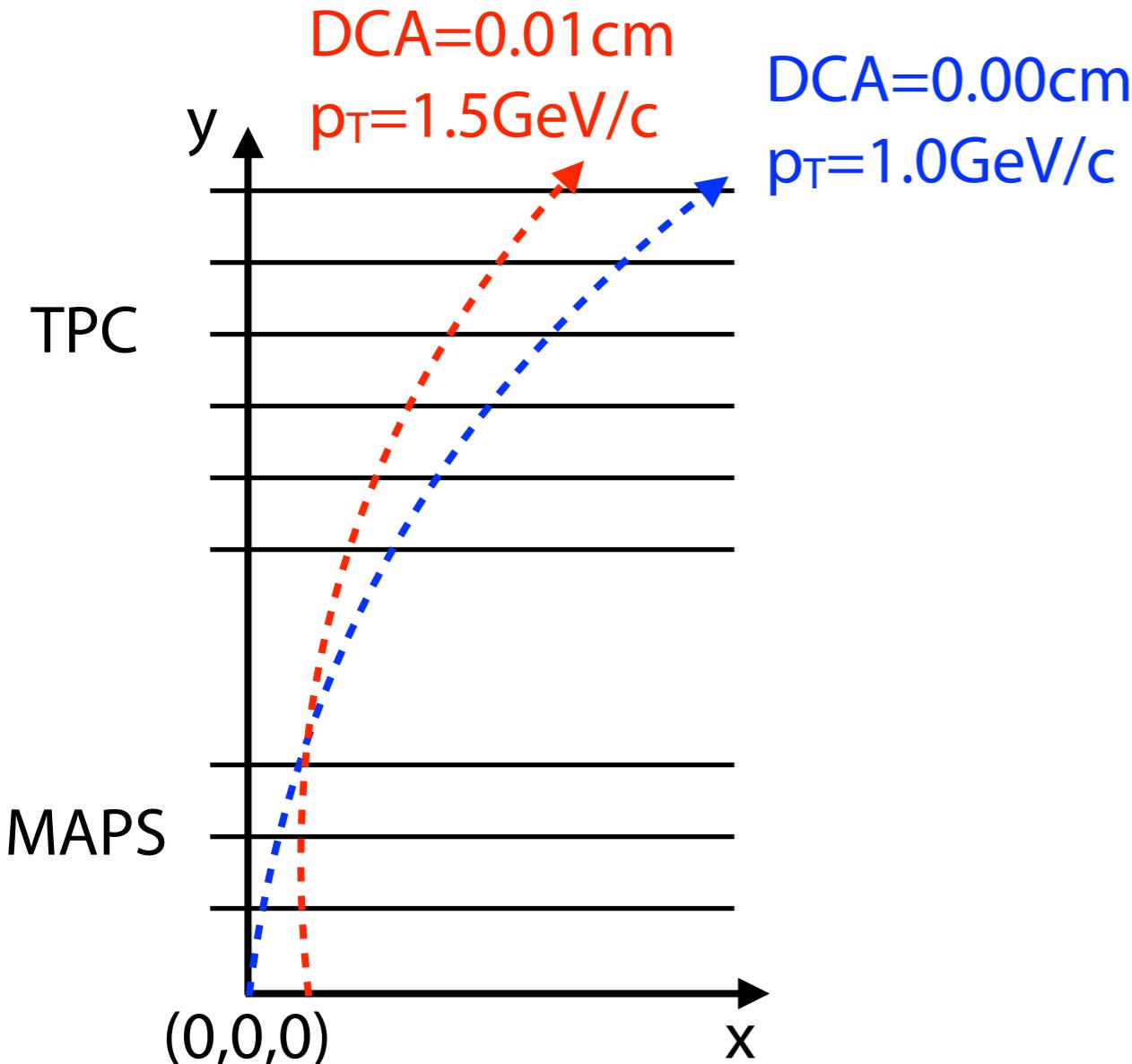
- Additional material?

- In my understanding, the current Hough transform code assumes that a track to be a complete helix and does not consider a bent of tracks due to multiple scatterings.
- Does a tuning of the Hough spaces binning improve performance? or use a multi-circle fit that has been used for PHENIX VTX.

- Pattern recognition bias?

- Do additional layers by INTT faulty work due to ghost rejection or some other parts...
- I checked how two adjacent tracks are reconstructed in a simple event configuration.

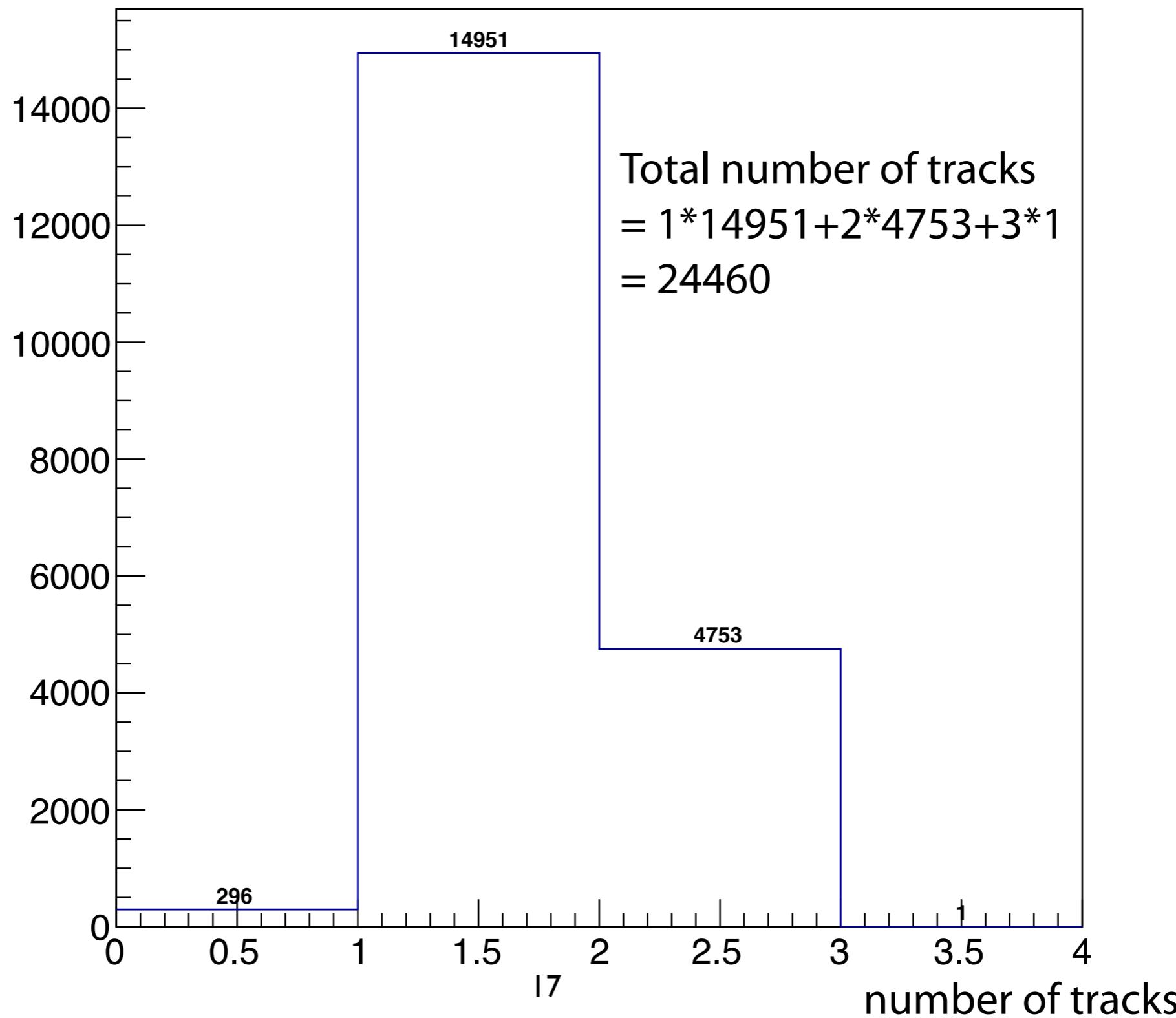
Reconstruction of two adjacent tracks



- Only two particles are emitted per event; from $(0, 0, 0)$ at $p_T = 1.0 \text{ GeV}/c$ and from $(0.01, 0, 0)$ at $p_T = 1.5 \text{ GeV}/c$.
- If reconstruction perfectly works, two tracks are successfully found.
- If reconstruction is confused, one track is found.
 - $1.0 \text{ GeV}/c$ and $1.5 \text{ GeV}/c$ equally
 - $1.0 \text{ GeV}/c$ track at TPC is connected to $1.5 \text{ GeV}/c$ track at MAPS, vice versa.
- If reconstruction is biased, either $1.0 \text{ GeV}/c$ or $1.5 \text{ GeV}/c$ track is preferably chosen.

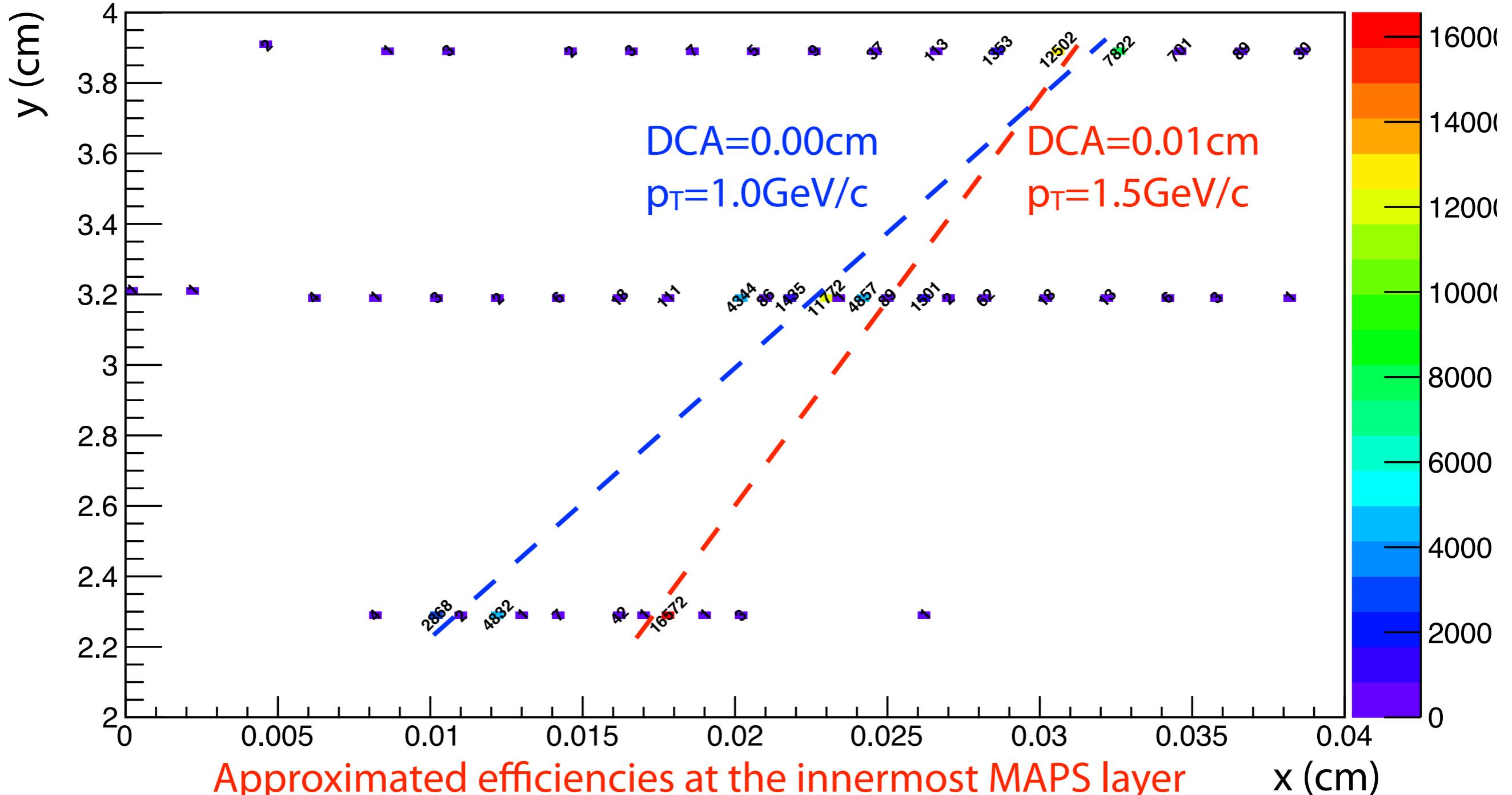
Number of reconstructed tracks

Simulated 2 tracks/event x 20000 events



Number of clusters at MAPS

Simulated 2 tracks/event x 20000 events



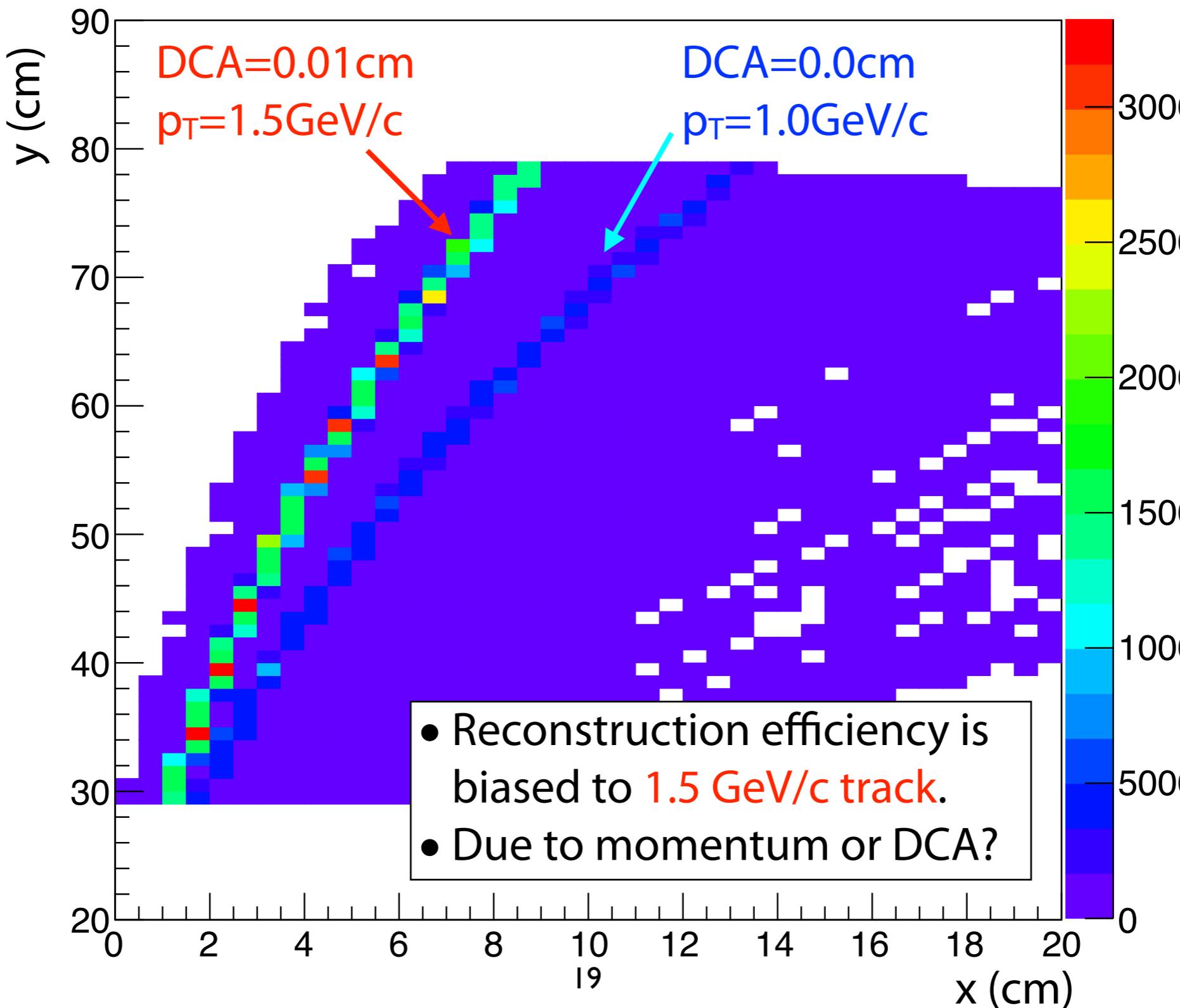
Approximated efficiencies at the innermost MAPS layer

DCA=0.00cm && p_T=1.0GeV/c: (2868+4832)/20000 = 0.39

DCA=0.01cm && p_T=1.5GeV/c: 16572/20000 = 0.83

Number of clusters at TPC

Simulated 2 tracks/event x 20000 events



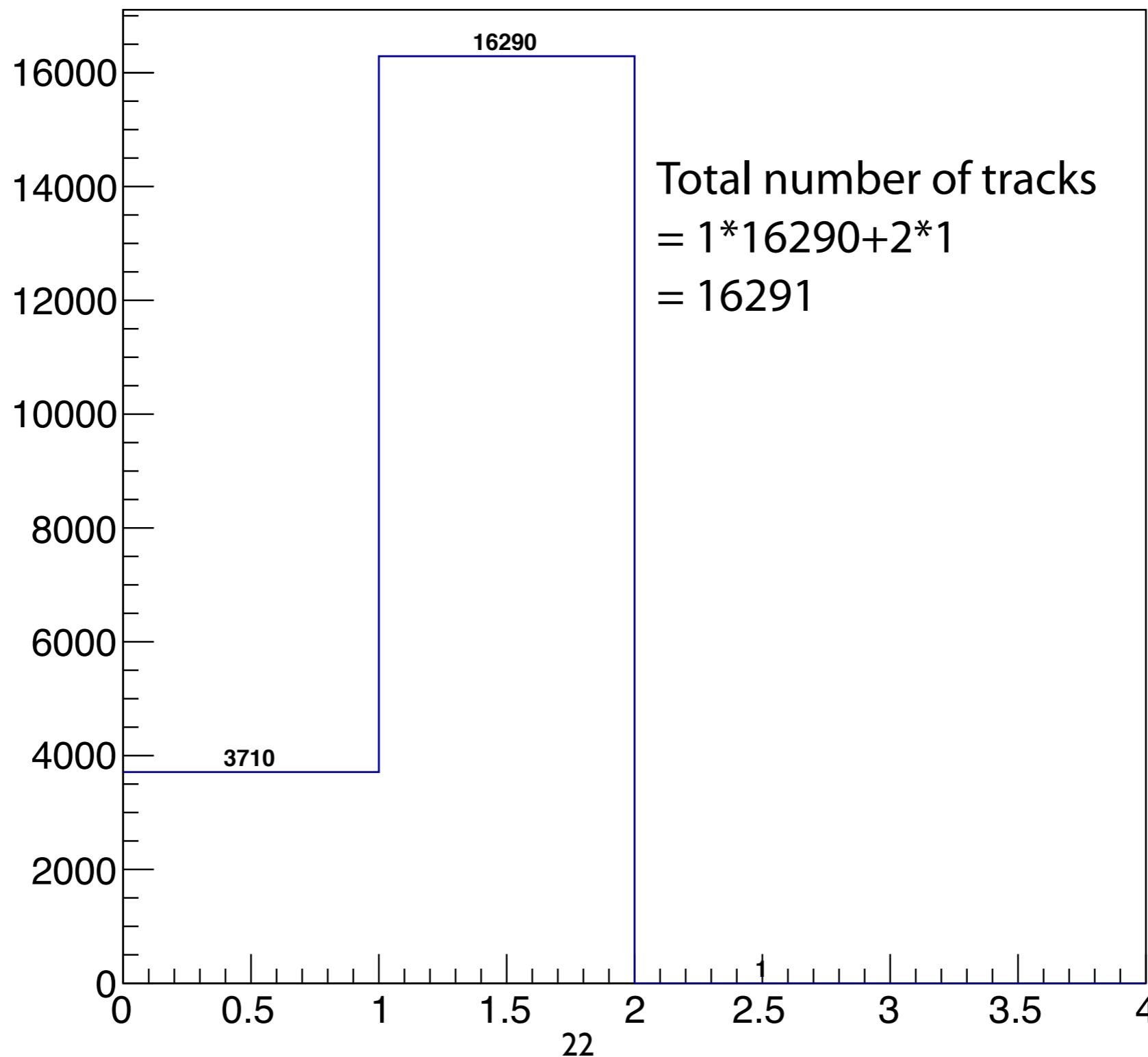
Summary

- I have looked at the DCA2D distributions assuming several detector configurations.
- I expected that INTT helped to link two tracklets between MAPS and TPC, but it looked not in the current G4 and reconstruction frameworks.
- Is it because the pattern recognition does not consider multiple scatterings or is biased? Need to study more in detail.

Backup

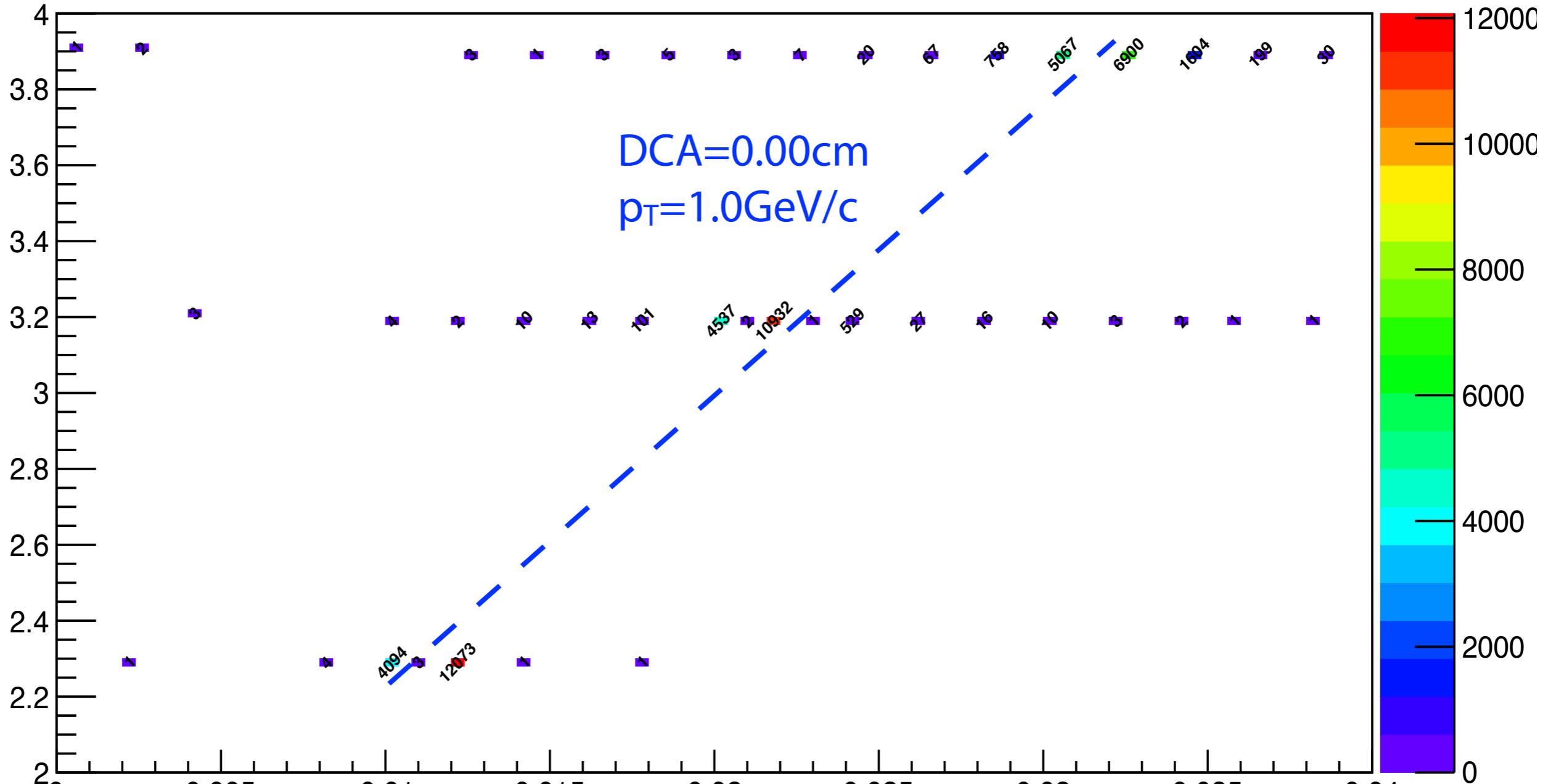
Number of reconstructed tracks

1tracks/event x 2000events



Number of clusters at MAPS

1tracks/event x 2000events

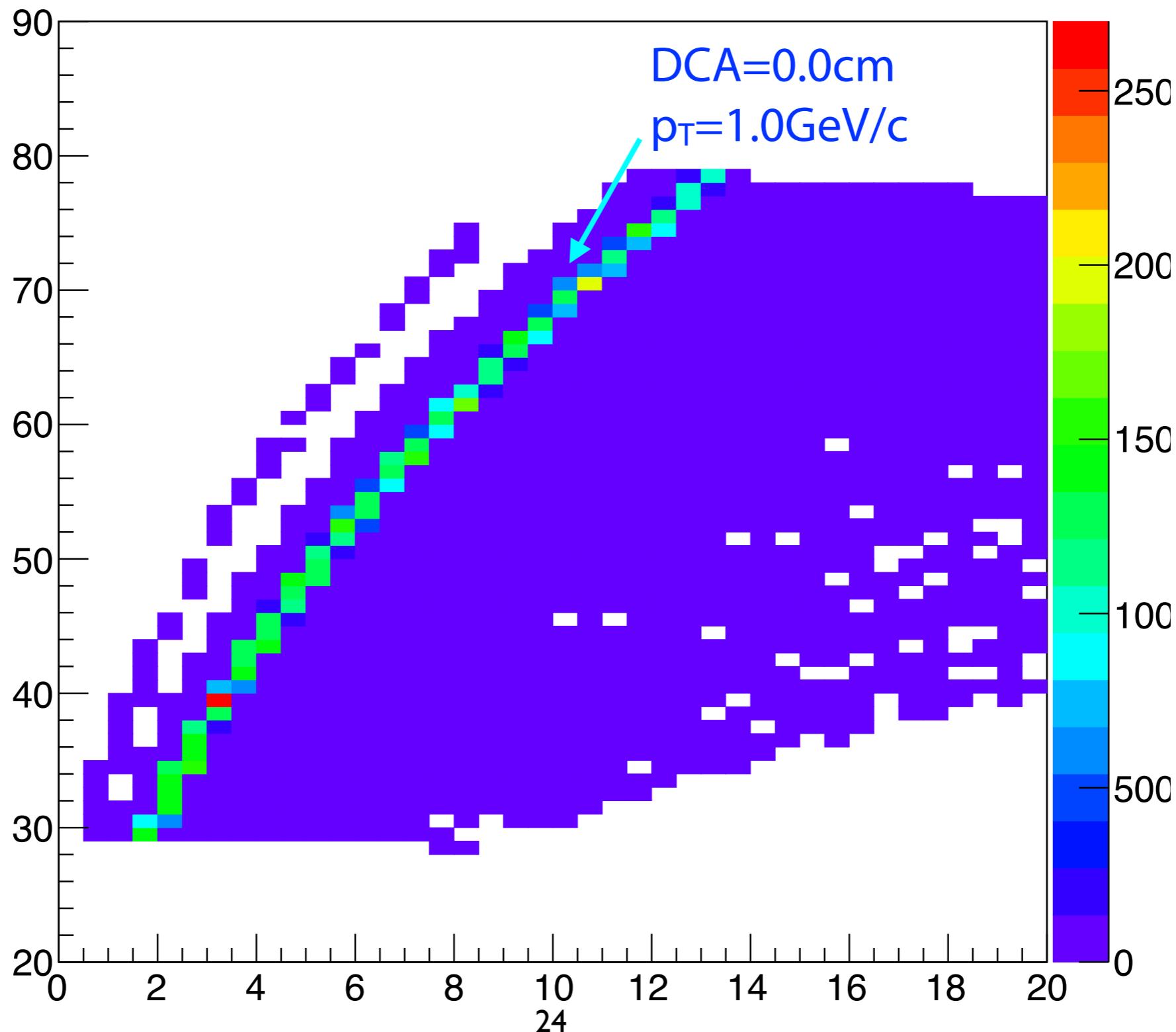


Approximated efficiencies at the innermost MAPS layer

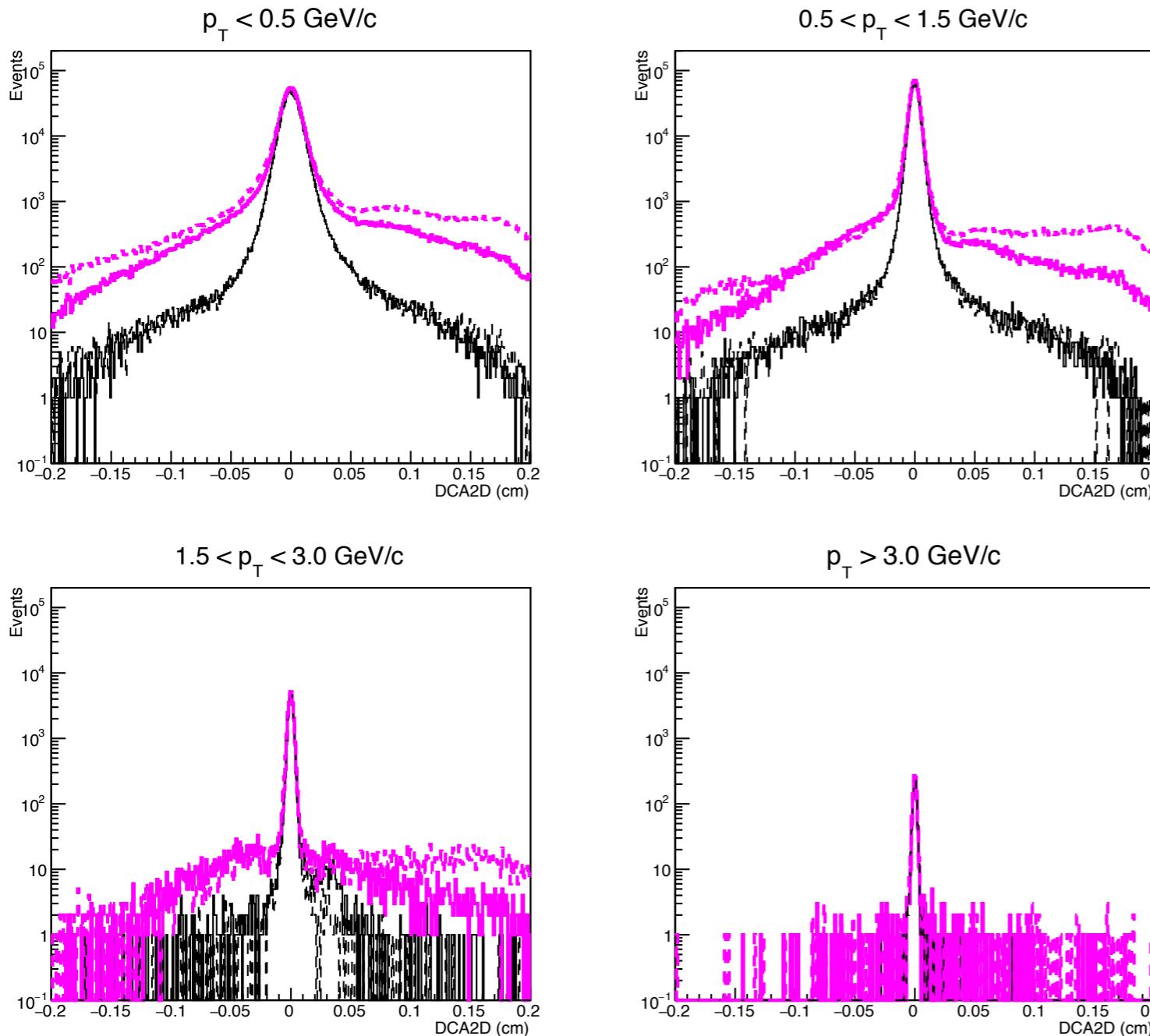
DCA=0.00cm && p_T=1.0GeV/c: (4094+12073)/16291 = 0.99

Number of clusters at TPC

1tracks/event x 2000events



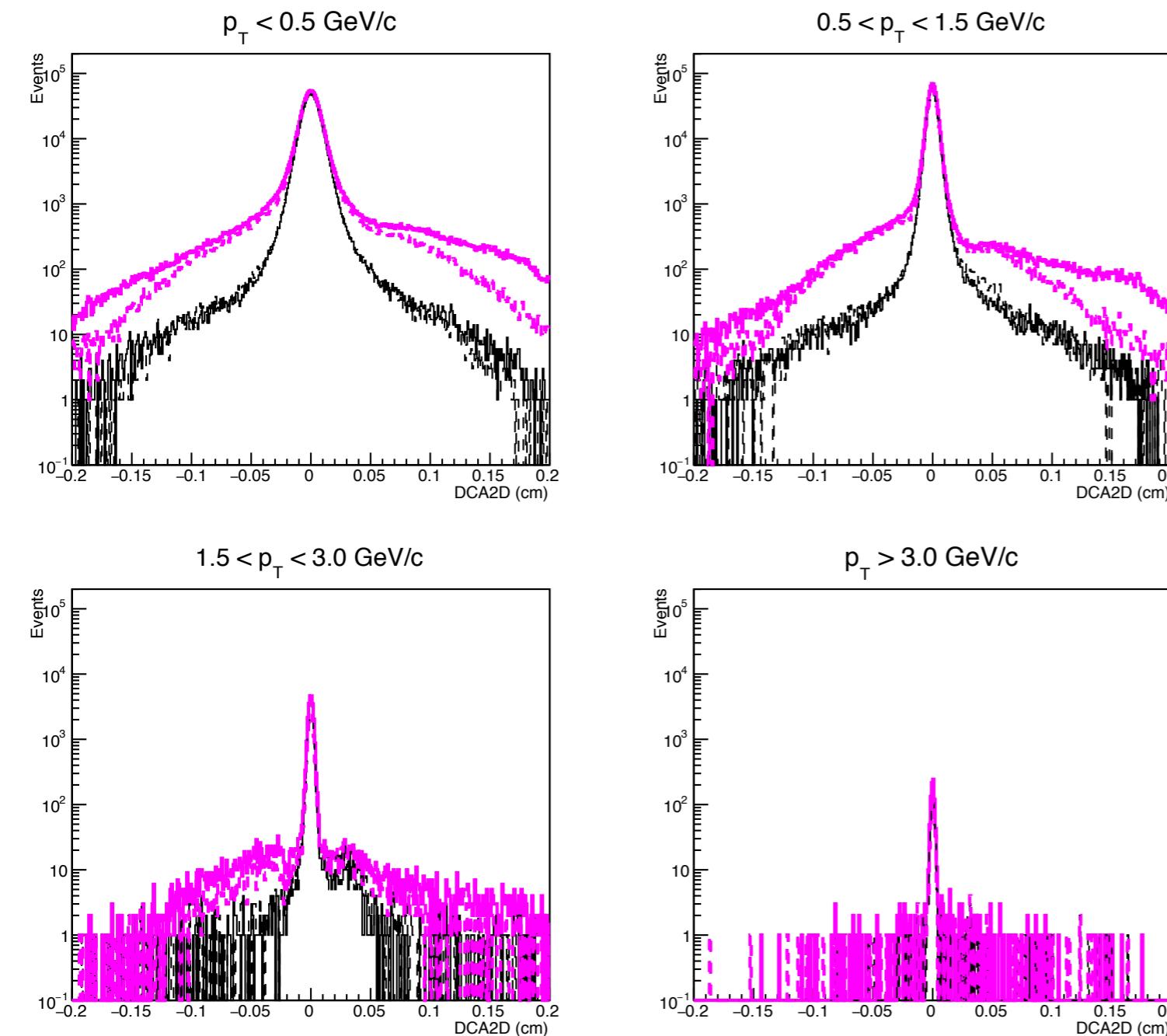
Config. 3.4, requested hits dependence



		MAPS layer		
		0	1	2
Black	TRUE	TRUE	TRUE	
	Magenta	Sum of all combinations		

Solid: requested hits = all layers-6
 Dashed: requested hits = all layers-9

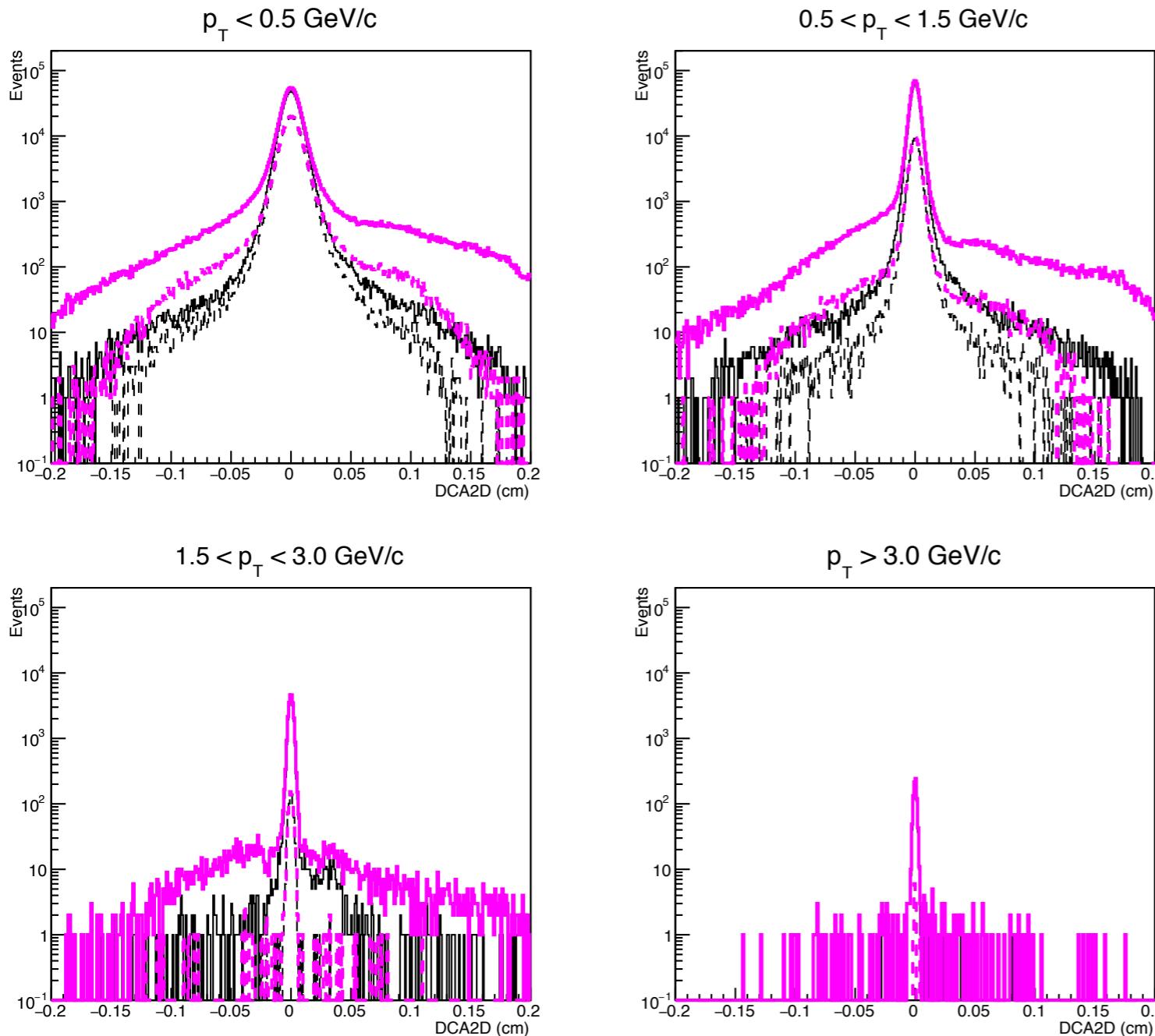
Config. 3.4, requested hits dependence



		MAPS layer		
		0	1	2
Black	TRUE	TRUE	TRUE	
	Magenta	Sum of all combinations		

Solid: requested hits = all layers-6
 Dashed: requested hits = all layers-3

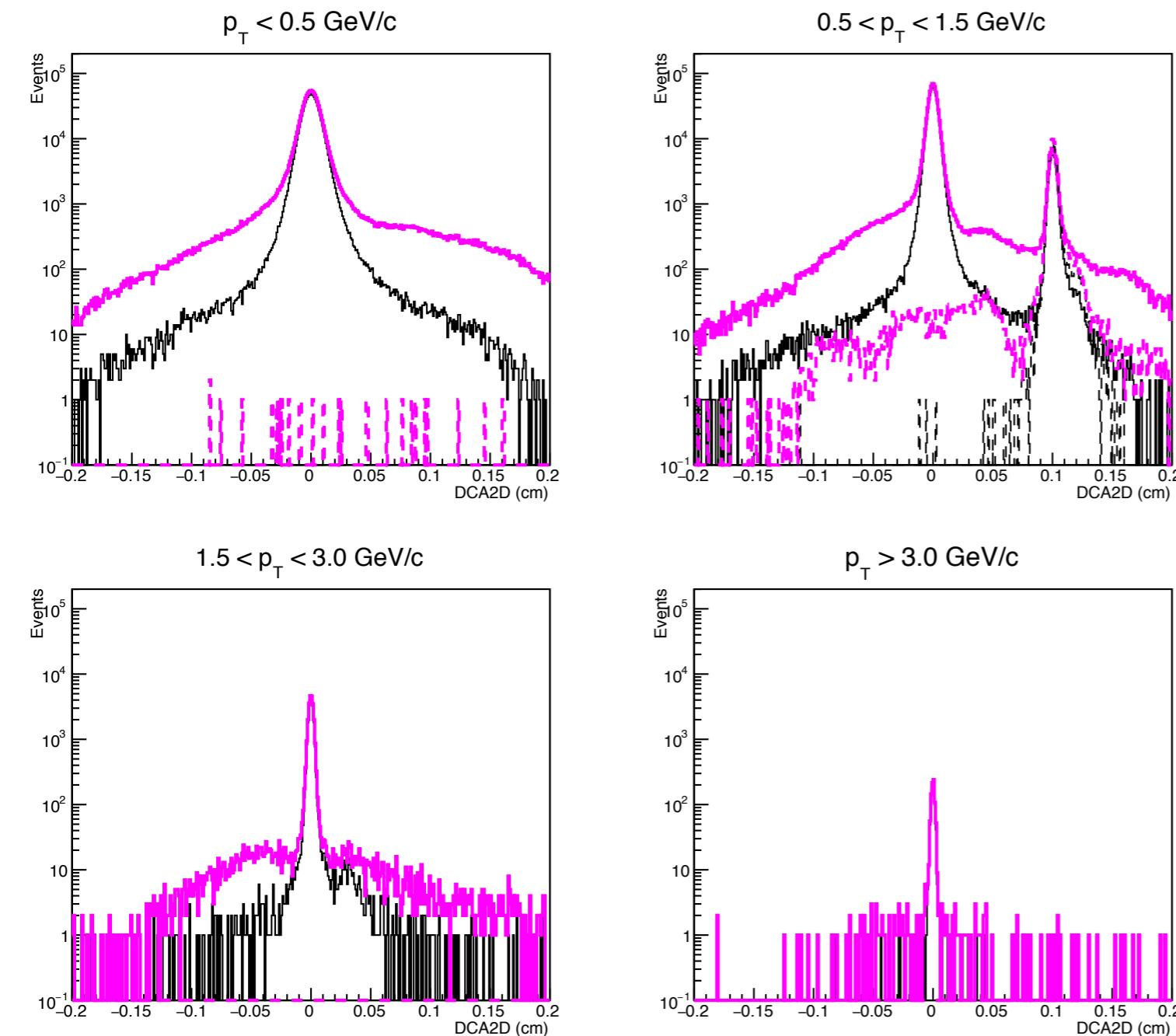
Config. 3.4, requested hits dependence



		MAPS layer		
		0	1	2
Black	TRUE	TRUE	TRUE	
	Magenta	Sum of all combinations		

Solid: requested hits = all layers-6
 Dashed: requested hits = all layers

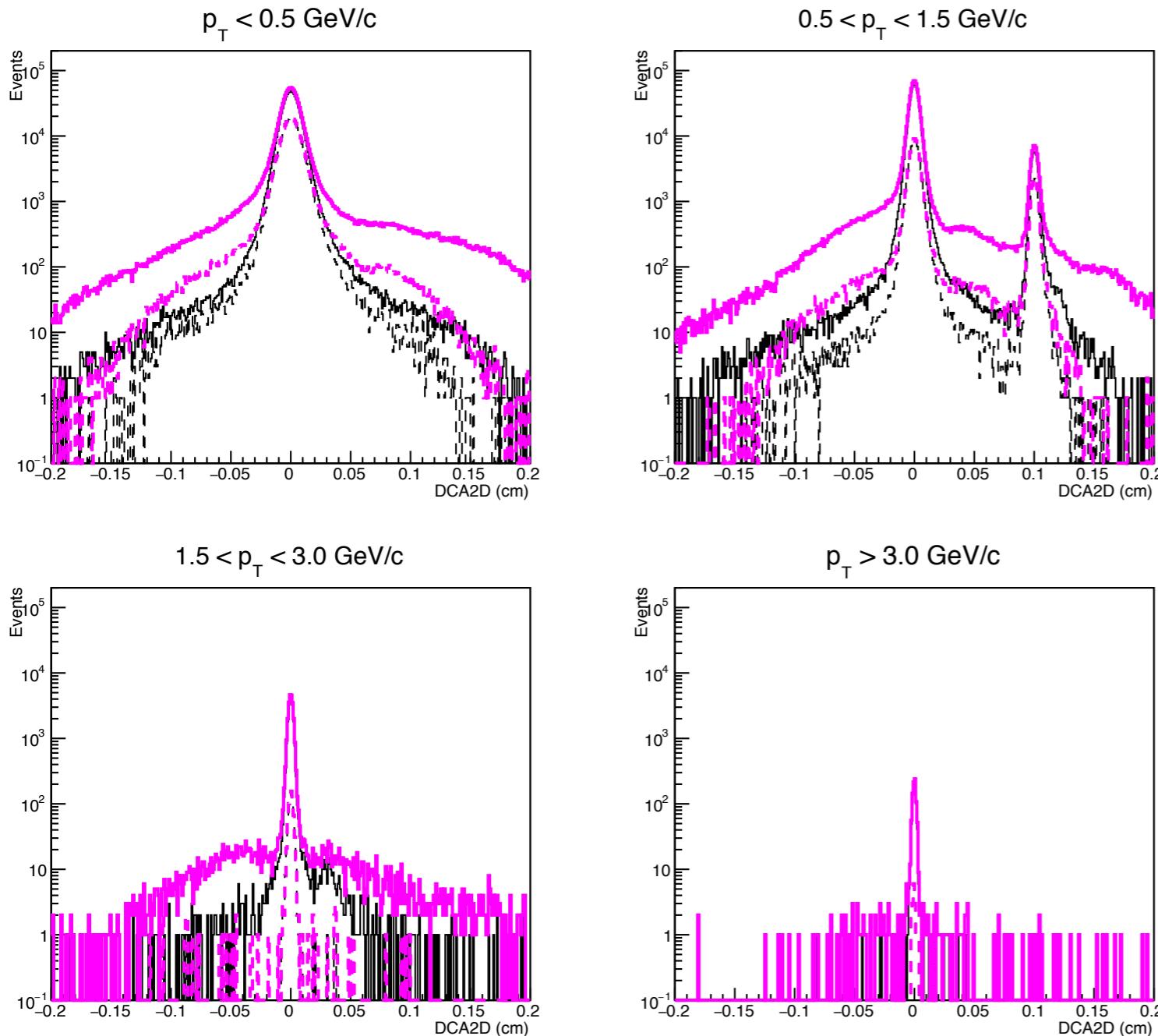
Config. 3.4, DCA=0.1cm



		MAPS layer		
		0	1	2
Black	TRUE	TRUE	TRUE	
	Magenta	Sum of all combinations		

Solid: DCA=0.1cm embed in HIJING
 Dashed: DCA=0.1cm single

Config. 3.4, DCA=0.1cm

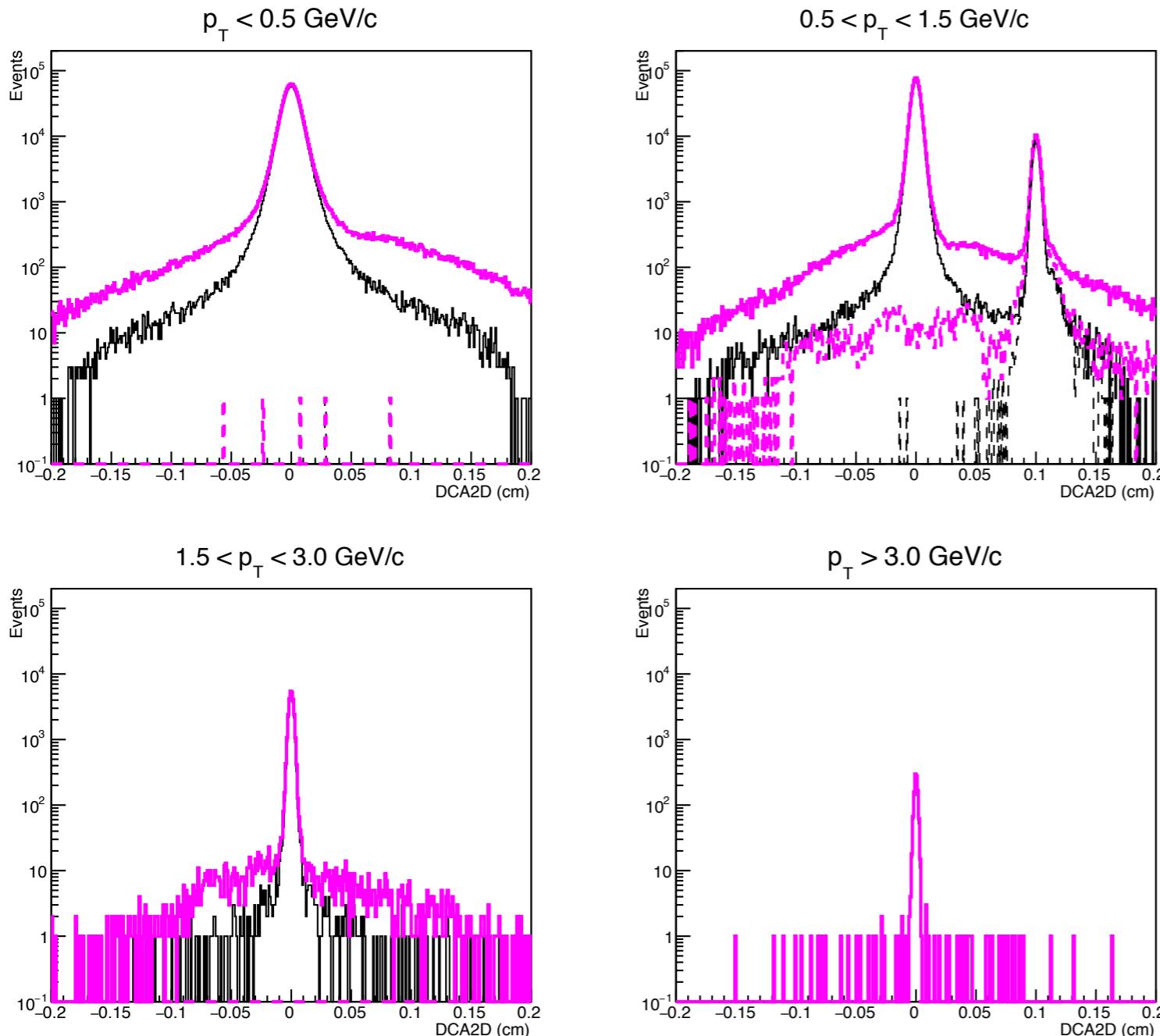


		MAPS layer		
		0	1	2
Black	TRUE	TRUE	TRUE	
	Magenta	Sum of all combinations		

Solid: DCA=0.1cm embed in HIJING
&& requested hits = all layers-6

Dashed: DCA=0.1cm embed in HIJING
&& requested hits = all layers

Config. 3.0, DCA=0.1cm

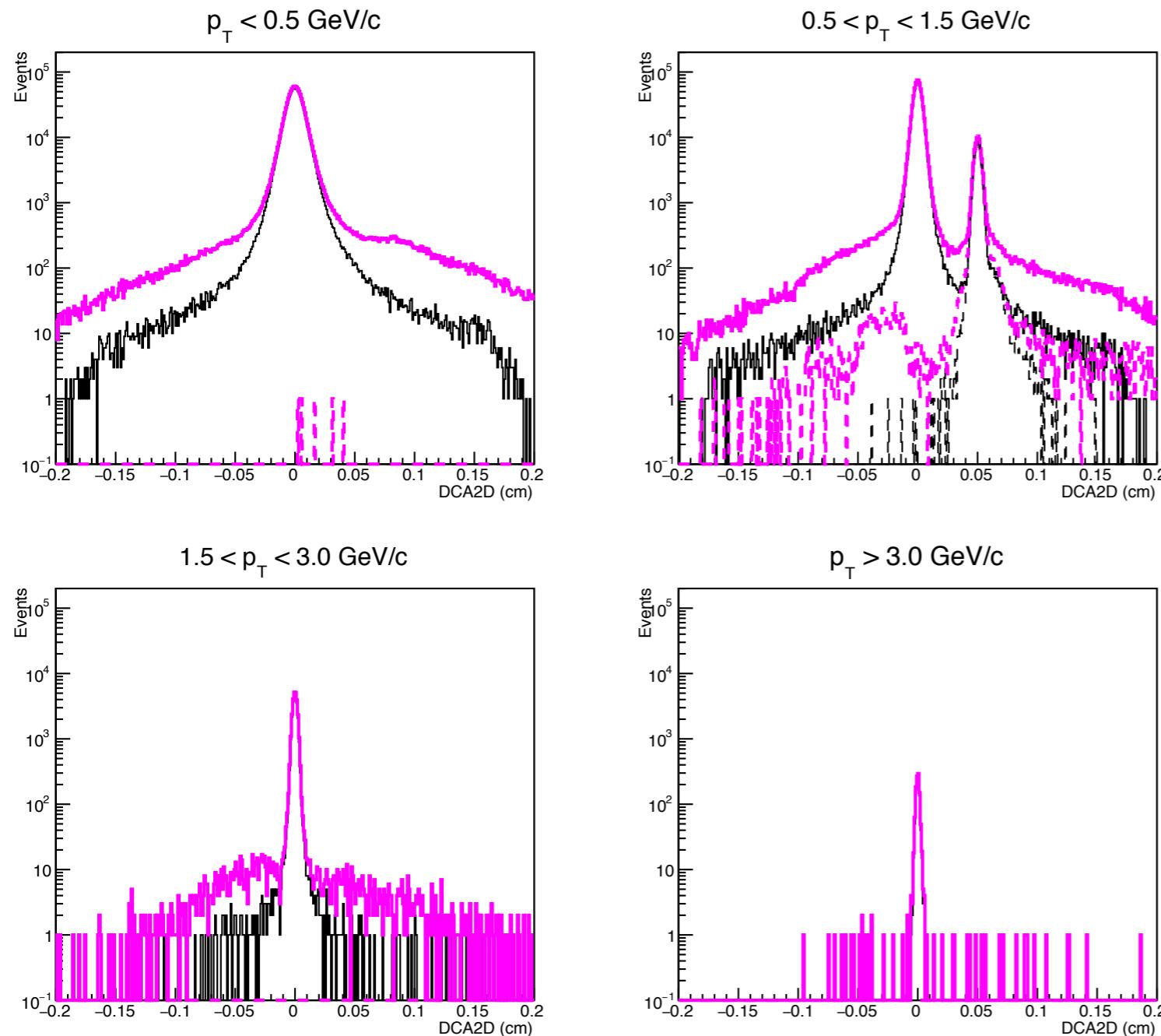


		MAPS layer		
		0	1	2
Black	TRUE	TRUE	TRUE	
	Magenta	Sum of all combinations		

Solid: DCA=0.1cm embed in HIJING
 Dashed: DCA=0.1cm single

Peak height of the best-fit Gaussian
 DCA=0.000cm: $7.31765\text{e+}04 \pm 1.20528\text{e+}02$
 DCA=0.100cm: $9.49701\text{e+}03 \pm 4.80976\text{e+}01$
 Ratio(0.100/0.000) = 0.1298 ± 0.0007

Config. 3.0, DCA=0.05cm

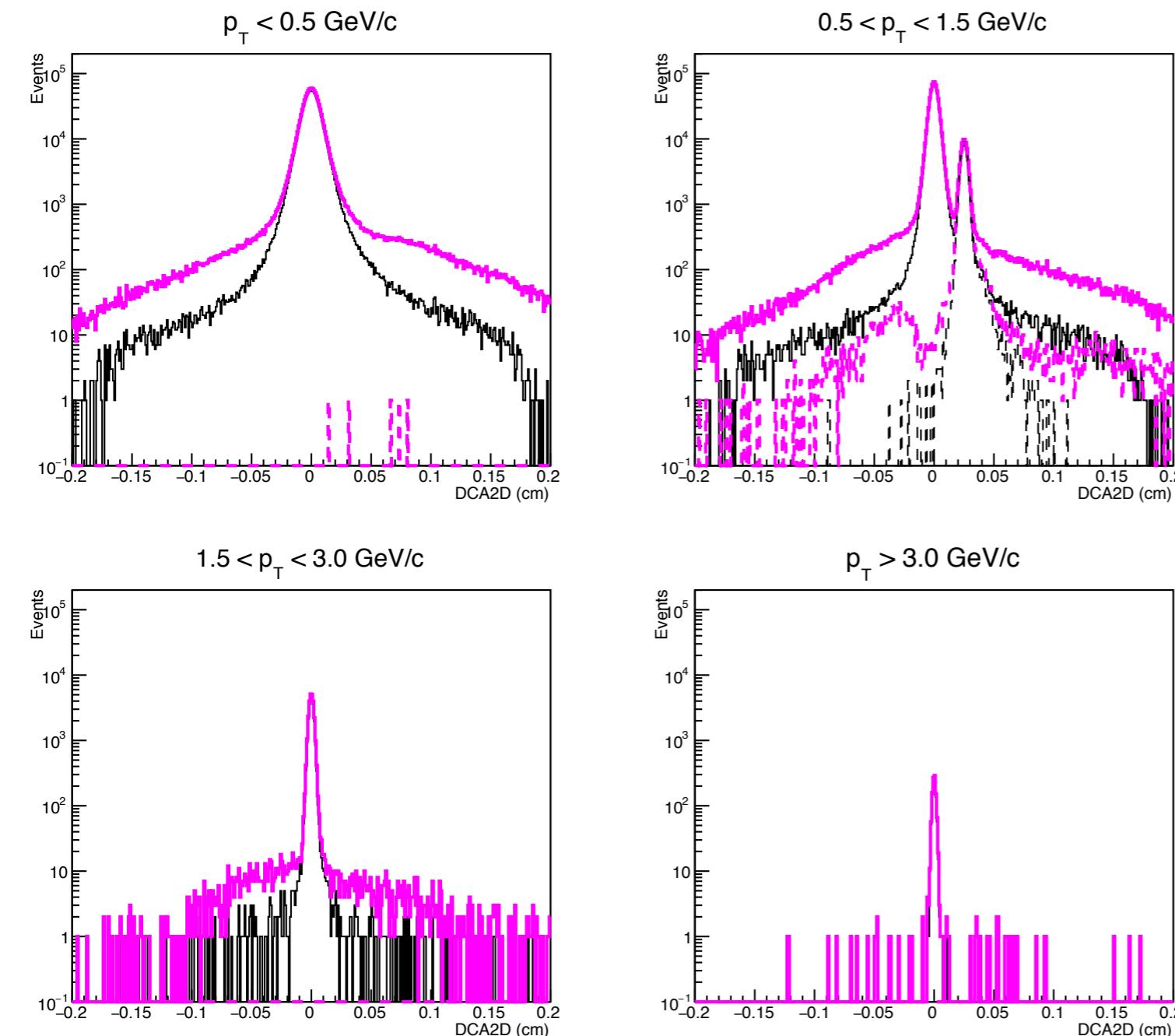


	MAPS layer		
	0	1	2
Black	TRUE	TRUE	TRUE
Magenta	Sum of all combinations		

Solid: DCA=0.05cm embed in HIJING
 Dashed: DCA=0.05cm single

Peak height of the best-fit Gaussian
 DCA=0.000cm: $7.08440\text{e+}04$ +/- $1.18484\text{e+}02$
 DCA=0.050cm: $9.66165\text{e+}03$ +/- $4.94211\text{e+}01$
 Ratio(0.050/0.000) = 0.1364 +/- 0.0007

Config. 3.0, DCA=0.025cm

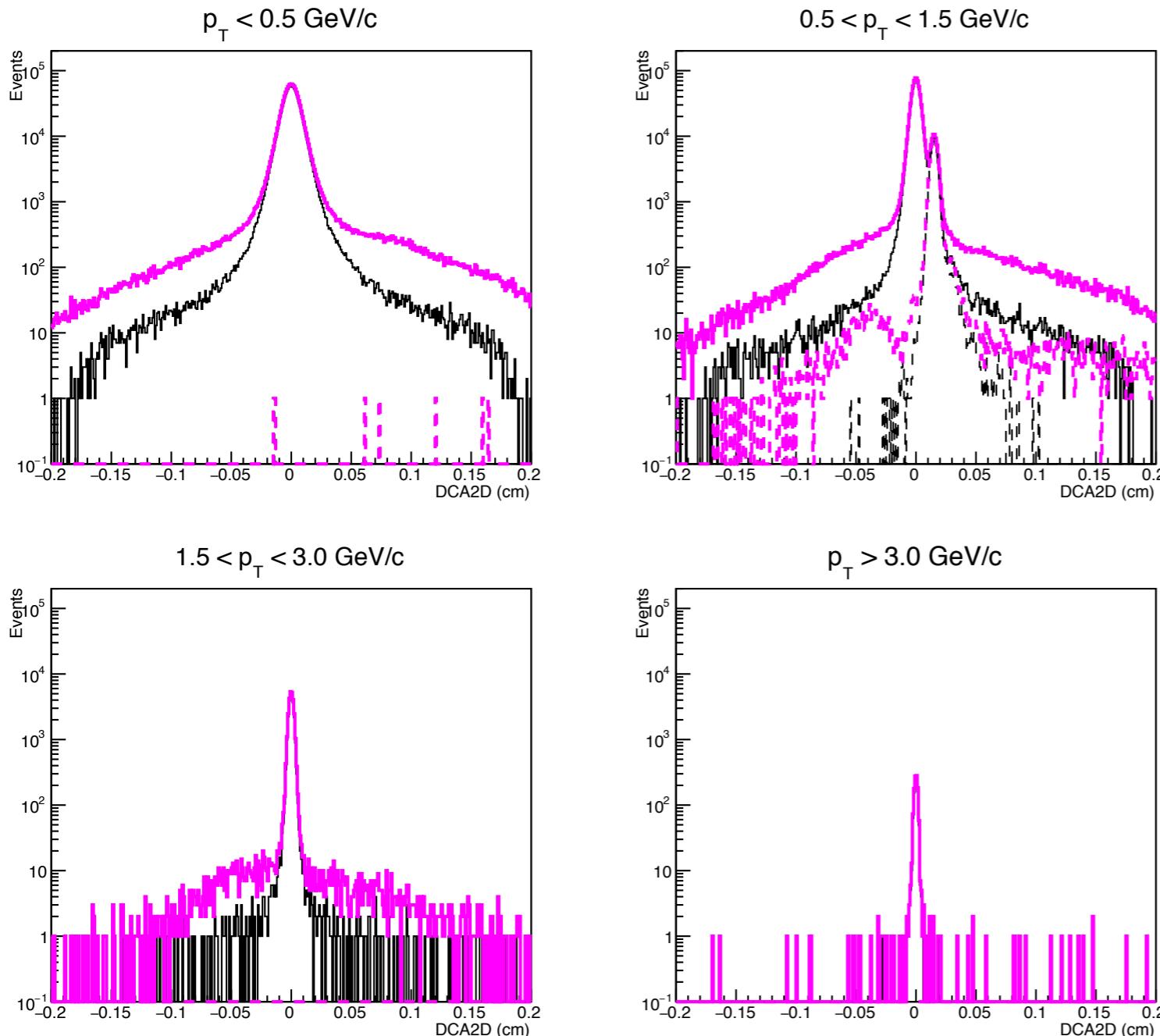


		MAPS layer		
		0	1	2
Black	TRUE	TRUE	TRUE	
	Magenta	Sum of all combinations		

Solid: DCA=0.025cm embed in HIJING
 Dashed: DCA=0.025cm single

Peak height of the best-fit Gaussian
 DCA=0.000cm: $7.05457\text{e+}04$ +/- $1.18474\text{e+}02$
 DCA=0.025cm: $9.52234\text{e+}03$ +/- $5.03476\text{e+}01$
 Ratio(0.025/0.000) = 0.1350 +/- 0.0007

Config. 3.0, DCA=0.015cm

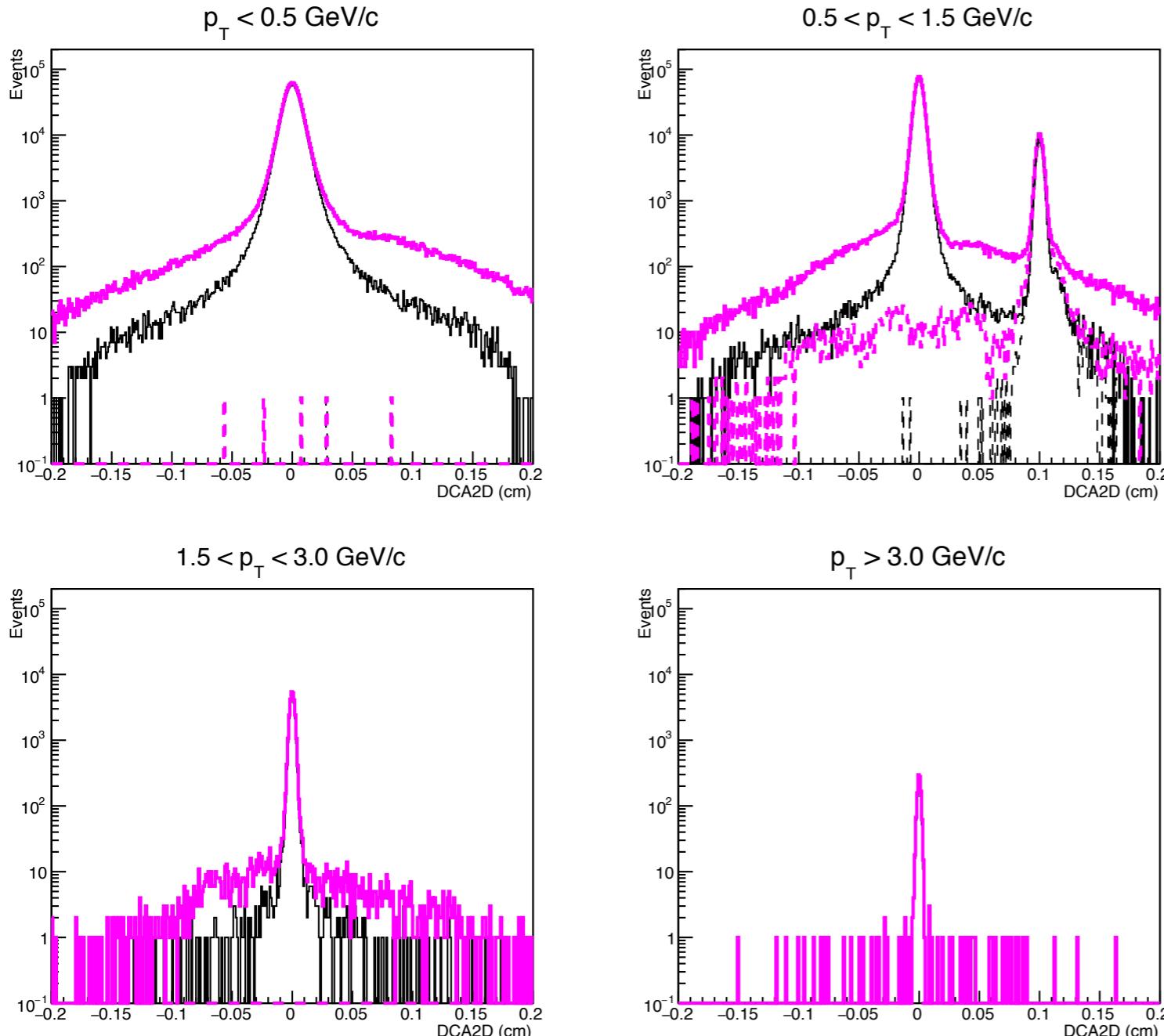


		MAPS layer		
		0	1	2
Black	TRUE	TRUE	TRUE	
	Magenta	Sum of all combinations		

Solid: DCA=0.015cm embed in HIJING
 Dashed: DCA=0.015cm single

Peak height of the best-fit Gaussian
 DCA=0.000cm: $7.40252\text{e+}04 \pm 1.21767\text{e+}02$
 DCA=0.015cm: $1.00842\text{e+}04 \pm 5.08880\text{e+}01$
 Ratio(0.015/0.000) = 0.1362 ± 0.0007

Config. 3.0, DCA=0.1cm (TPC cell size)



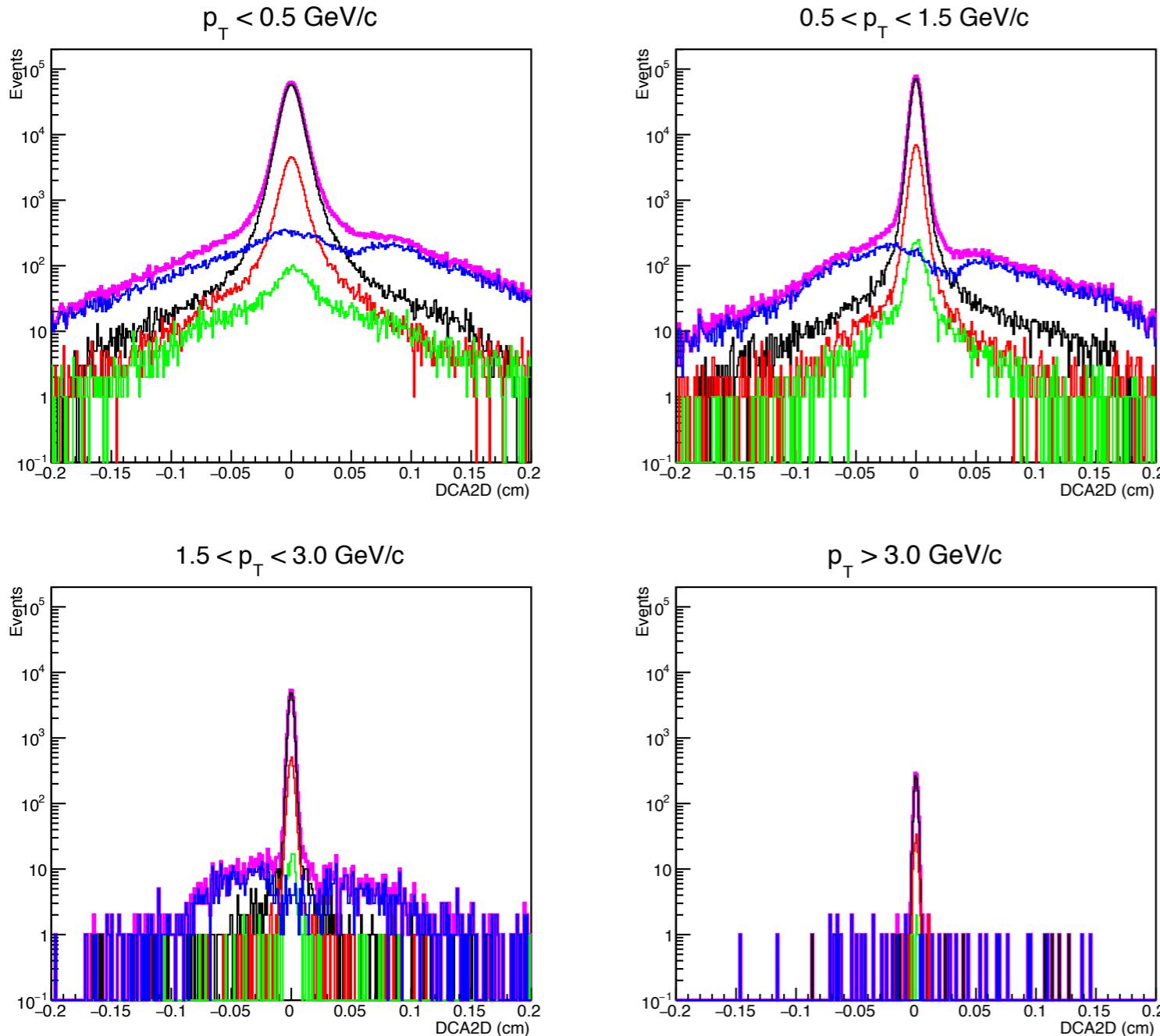
		MAPS layer		
		0	1	2
Black	TRUE	TRUE	TRUE	
	Magenta	Sum of all combinations		

Solid: DCA=0.1cm embed in HIJING
Dashed: DCA=0.1cm single

Peak height of the best-fit Gaussian
DCA=0.000cm: $7.31765\text{e+}04 \pm 1.20528\text{e+}02$
DCA=0.100cm: $9.49701\text{e+}03 \pm 4.80976\text{e+}01$
Ratio(0.100/0.000) = 0.1298 ± 0.0007

Ratio(wide/narrow)
~3.3 at DCA=0.0cm
~3.1 at DCA=0.1cm

Config. 3.0



The number of inner layers = 3

0 fake	Black
1 fake	Red
2 fake	Green
3 fake	Blue
0-3 fakes	Magenta

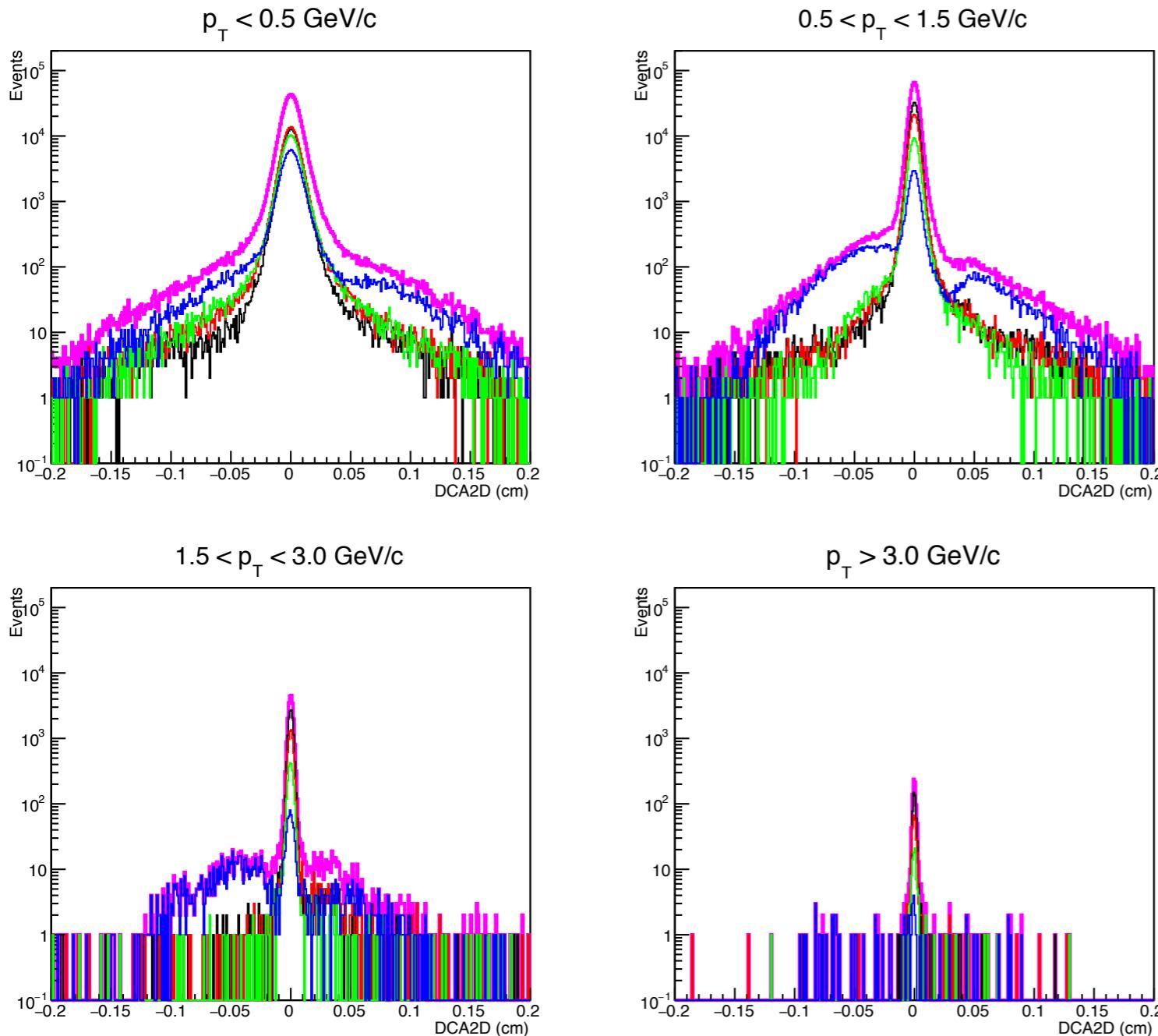
The number of entries

fake	0	1	2	3	0-3
<0.5GeV	960702	85804	6692	54635	1107833
0.5-1.5GeV	612725	70386	4707	28282	716100
1.5-3.0GeV	24895	2862	156	1102	29015
>3.0GeV	968	125	6	43	1142

Ratios to 0-3 fake entry

fake	0	1	2	3	0-3
<0.5GeV	0.867	0.077	0.006	0.049	1
0.5-1.5GeV	0.856	0.098	0.007	0.039	1
1.5-3.0GeV	0.858	0.099	0.005	0.038	1
>3.0GeV	0.848	0.109	0.005	0.038	1

Config. 3.4



The number of inner layers = 7

0 fake	Black
1 fake	Red
2 fake	Green
3 fake	Blue
0-3 fakes	Magenta

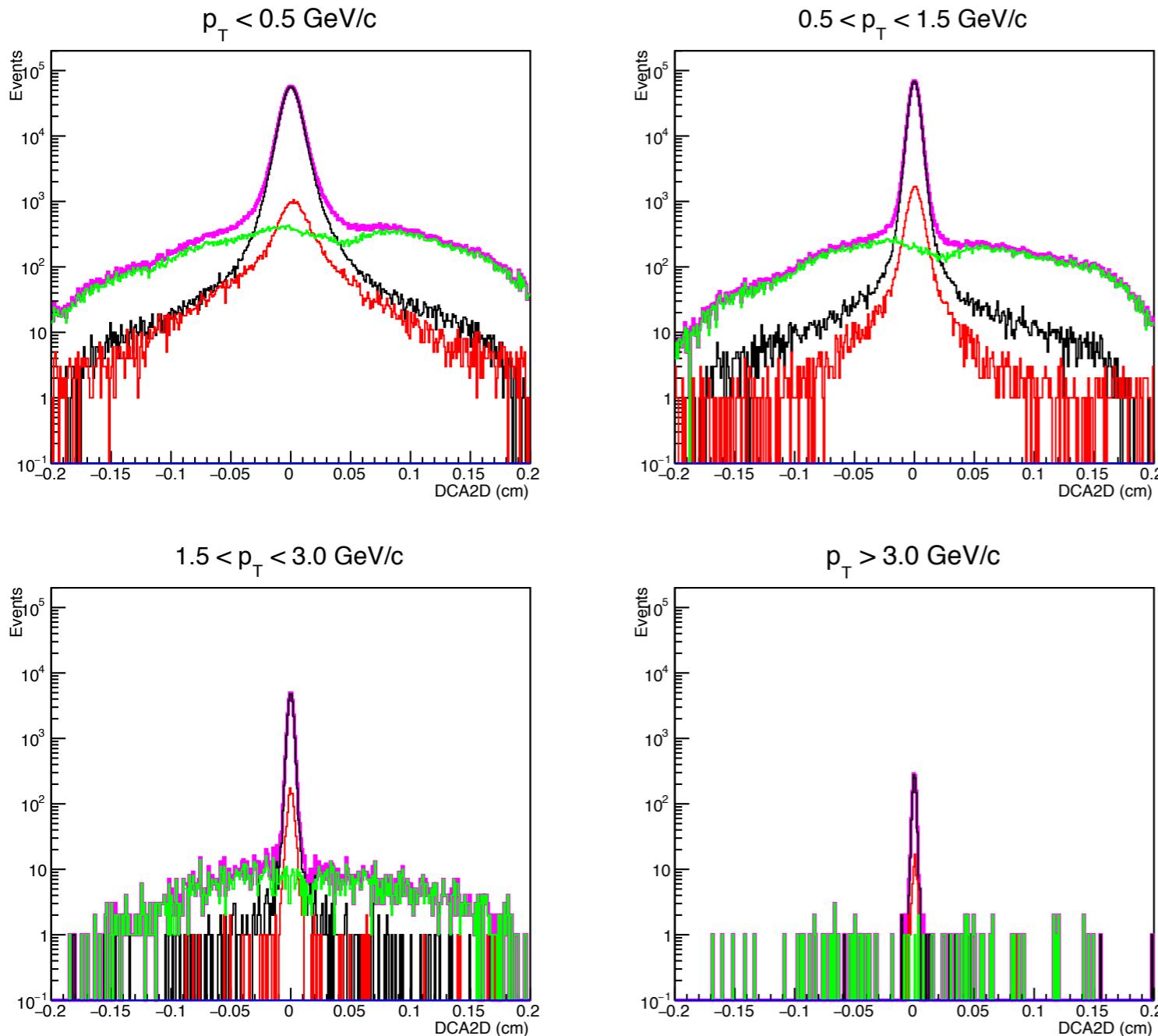
The number of entries

fake	0	1	2	3	0-3
<0.5GeV	192959	226559	179185	120424	719127
0.5-1.5GeV	272352	197846	92155	48200	610553
1.5-3.0GeV	13596	7291	2649	1554	25090
>3.0GeV	506	292	106	65	969

Ratios to 0-3 fake entry

fake	0	1	2	3	0-3
<0.5GeV	0.268	0.315	0.249	0.167	1
0.5-1.5GeV	0.446	0.324	0.151	0.079	1
1.5-3.0GeV	0.542	0.291	0.106	0.062	1
>3.0GeV	0.522	0.301	0.109	0.067	1

Config. 2.0



The number of inner layers = 2

0 fake	Black
1 fake	Red
2 fake	Green
3 fake	Blue
0-3 fakes	Magenta

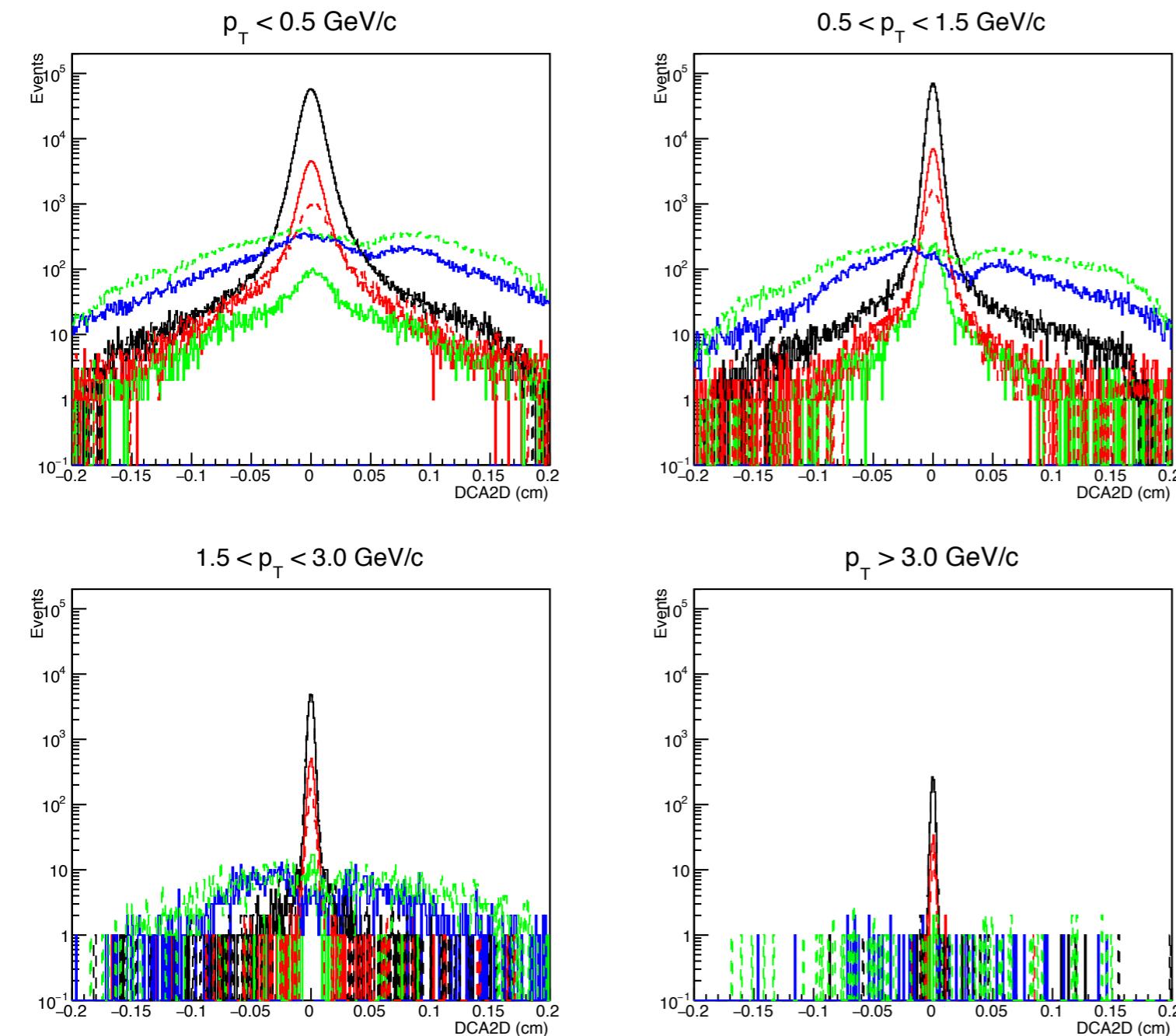
The number of entries

fake	0	1	2	3	0-3
<0.5GeV	949910	35604	84797	0	1070311
0.5-1.5GeV	621775	23963	49415	0	695153
1.5-3.0GeV	25370	1046	1745	0	28161
>3.0GeV	966	57	83	0	1106

Ratios to 0-3 fake entry

fake	0	1	2	3	0-3
<0.5GeV	0.888	0.033	0.079	0	1
0.5-1.5GeV	0.894	0.034	0.071	0	1
1.5-3.0GeV	0.901	0.037	0.062	0	1
>3.0GeV	0.873	0.052	0.075	0	1

Config. 3.0 (solid) vs. Config. 2.0 (dashed)

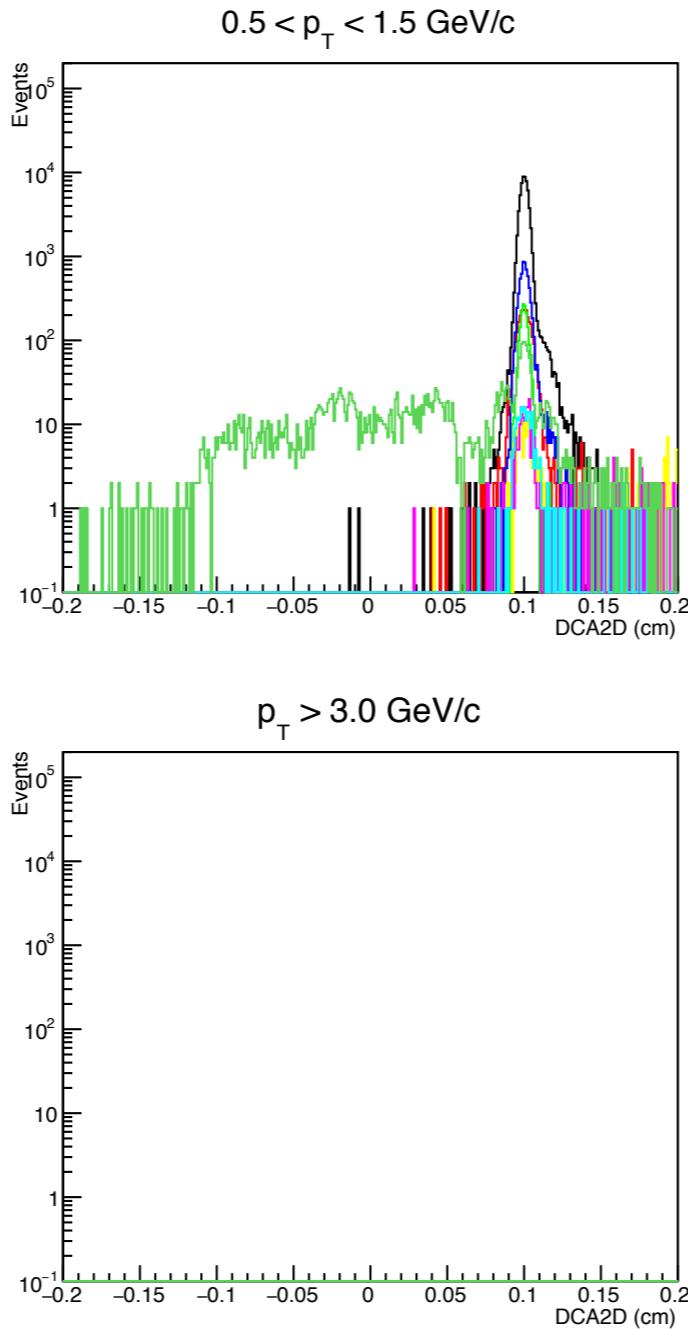
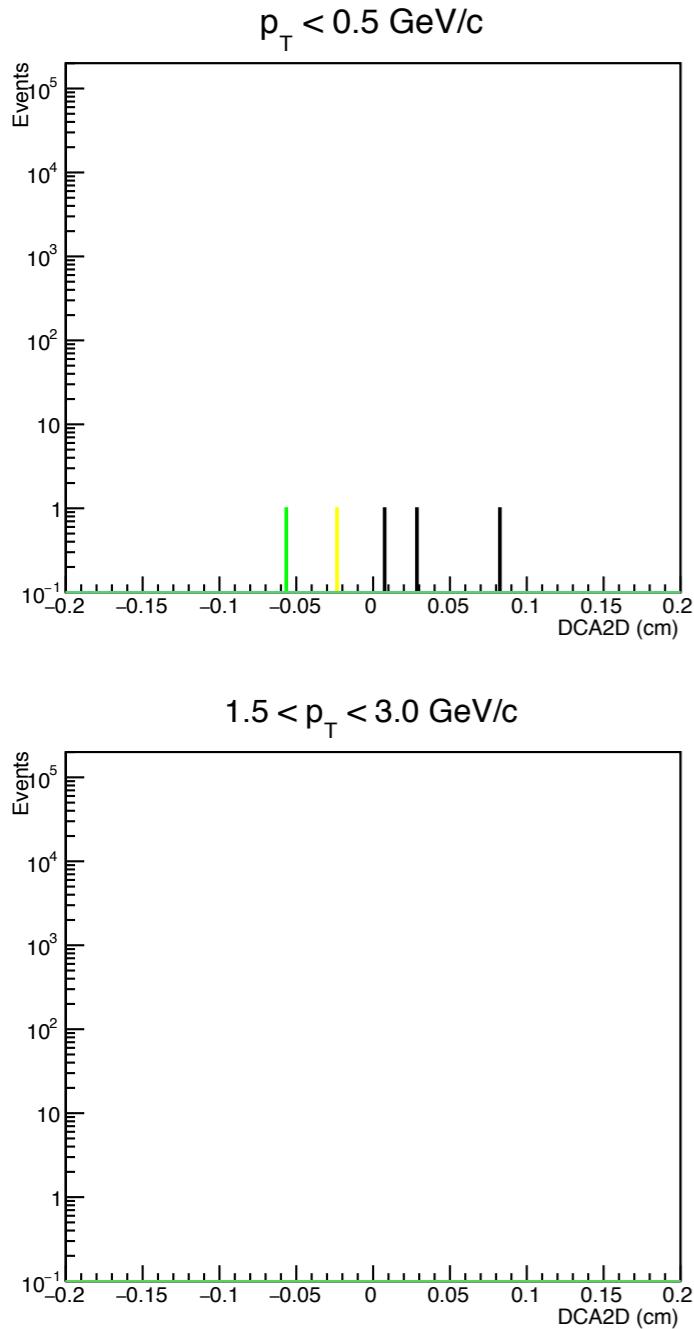


The number of inner layers = 2/3

0 fake	Black
1 fake	Red
2 fake	Green
3 fake	Blue
0-3 fakes	Magenta

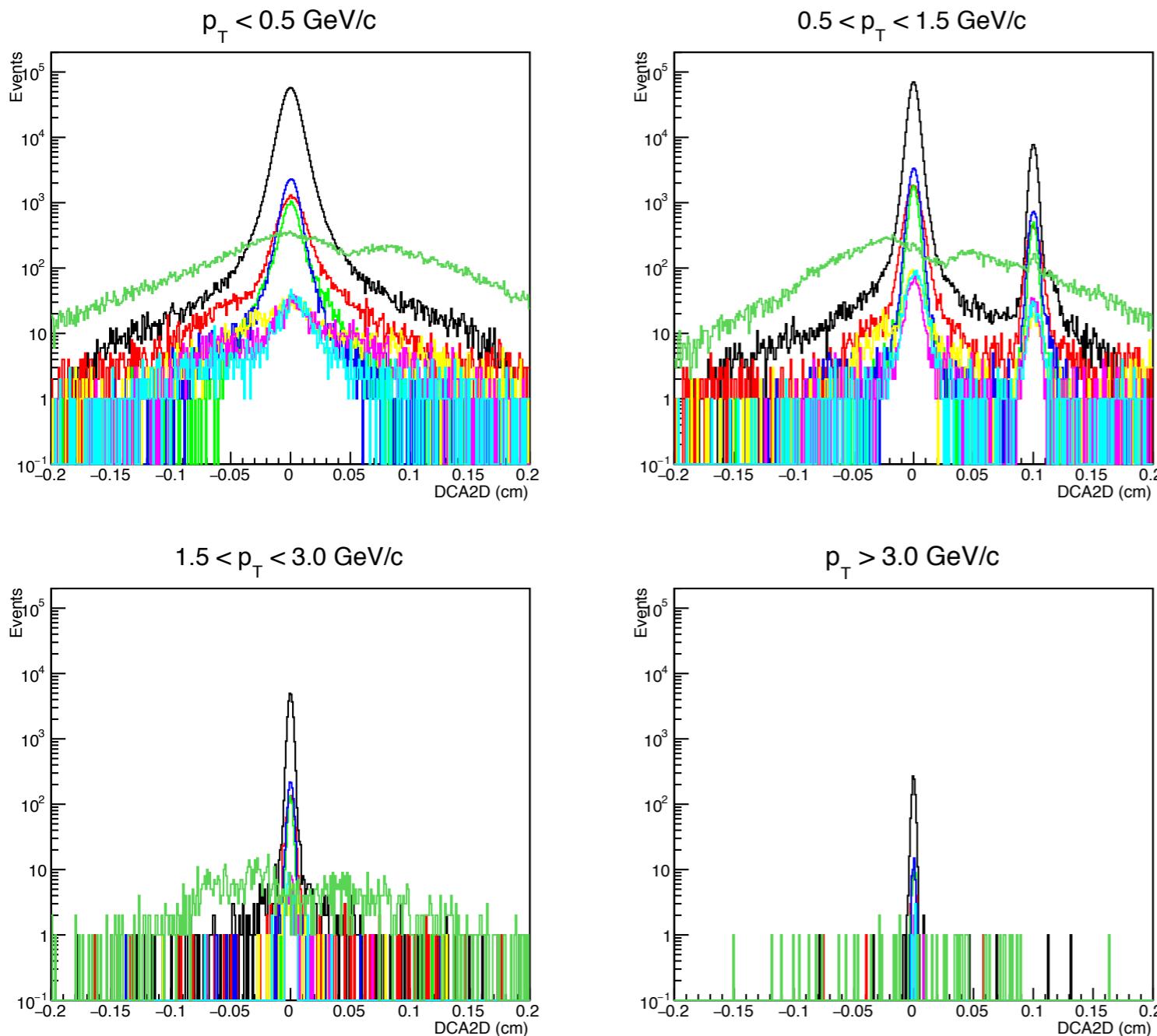
Events with DCA2D=0.1cm

Central HIJING



	MAPS layer		
	0	1	2
Black	TRUE	TRUE	TRUE
Red	FAKE	TRUE	TRUE
Green	TRUE	FAKE	TRUE
Blue	TRUE	TRUE	FAKE
Yellow	FAKE	FAKE	TRUE
Magenta	TRUE	FAKE	FAKE
Cyan	FAKE	TRUE	FAKE
moss green	FAKE	FAKE	FAKE

Events with DCA2D=0.1cm embed in HIJING



	MAPS layer		
	0	1	2
Black	TRUE	TRUE	TRUE
Red	FAKE	TRUE	TRUE
Green	TRUE	FAKE	TRUE
Blue	TRUE	TRUE	FAKE
Yellow	FAKE	FAKE	TRUE
Magenta	TRUE	FAKE	FAKE
Cyan	FAKE	TRUE	FAKE
moss green	FAKE	FAKE	FAKE

Backup

The number of entries (Slide6: Config. 3.0)

	Black	Red	Green	Blue	Yellow	Magenta	Cyan	Moss green
<0.5GeV	935364	31074	17324	35034	2647	2227	1543	53187
0.5-1.5GeV	596334	25062	13905	29370	2019	1092	1431	27734
1.5-3.0GeV	24266	936	621	1209	61	40	62	1019
>3.0GeV	921	46	34	58	4	3	2	36

The number of entries (slide7: Config. 3.4)

	Black	Red	Green	Blue	Yellow	Magenta	Cyan	Moss green
<0.5GeV	800715	44315	13438	56916	7077	33860	5644	102488
0.5-1.5GeV	546052	37993	10279	30061	5140	10556	2928	52033
1.5-3.0GeV	22285	879	444	1131	131	201	63	2053
>3.0GeV	843	36	18	47	4	2	6	85

	MAPS layer		
	0	1	2
Black	TRUE	TRUE	TRUE
Red	FAKE	TRUE	TRUE
Green	TRUE	FAKE	TRUE
Blue	TRUE	TRUE	FAKE
Yellow	FAKE	FAKE	TRUE
Magenta	TRUE	FAKE	FAKE
Cyan	FAKE	TRUE	FAKE
moss green	FAKE	FAKE	FAKE